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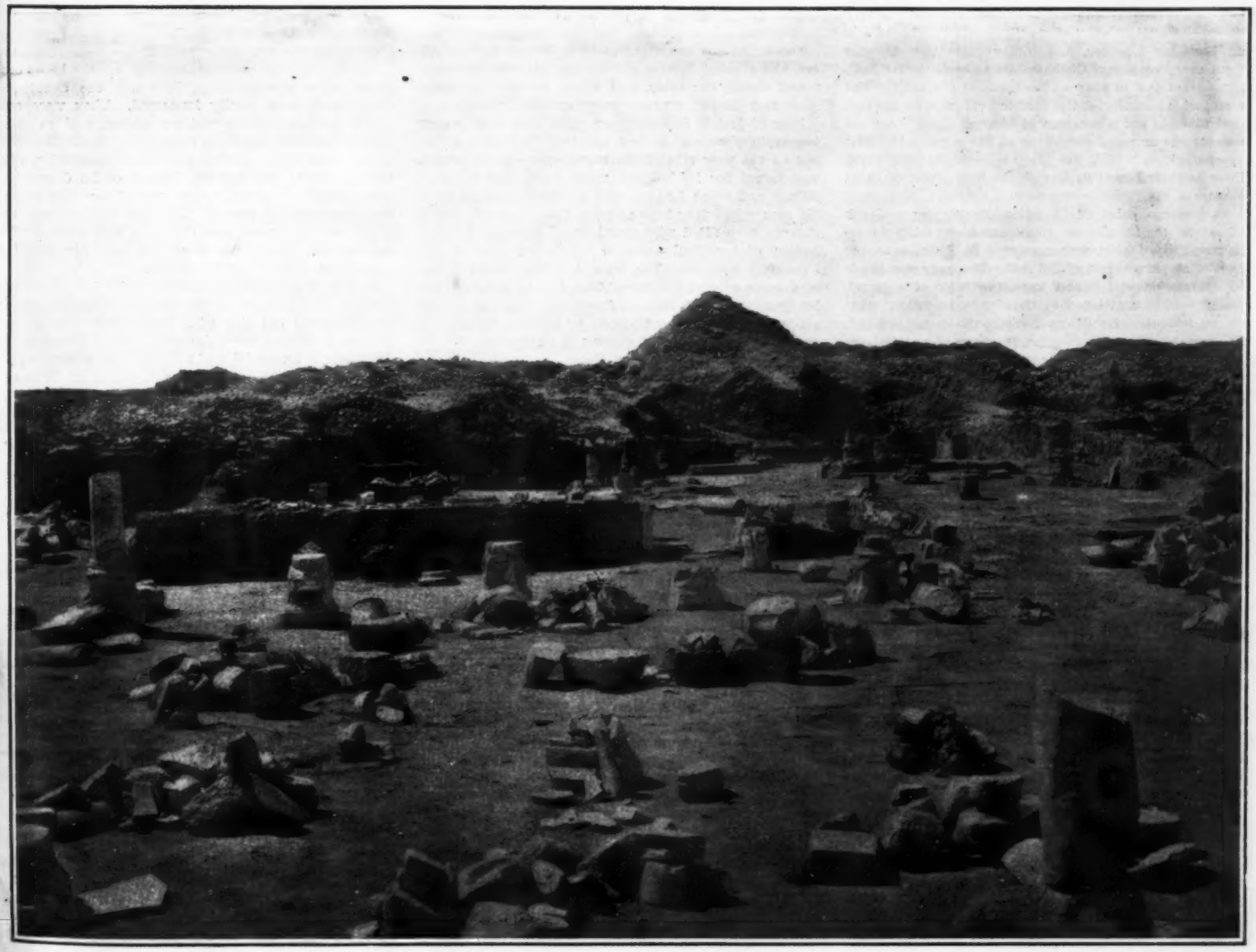
ENTRANCE TO THE CRYPT OF SAINT MENAS.

EXCAVATIONS IN THE BASILICA OF SAINT MENAS.



GENERAL VIEW OF THE SITE OF THE BASILICA OF ARCADIUS AT ABU MINA.

AN EGYPTIAN LOURDES: THE DISCOVERY OF THE LOST CITY OF SAINT MENAS.

AN EGYPTIAN LOURDES.

THE DISCOVERY OF THE LOST CITY OF SAINT MENAS.

BY E. ALEXANDER POWELL, F.R.G.S., M.N.G.S.A., ETC.

The cities of antiquity are almost all discovered. The day of great archæological finds has nearly passed. To the restless energy of a German priest and to a fragment of pottery which a Bedouin child was using for a toy, is due one of the most interesting archæological discoveries of recent times. After having been lost to the world for close on thirteen centuries, the sacred city of Abu Mina, the shrine of Saint Menas, has been found. That the ruins of a celebrated city, the holiest site in Christian Egypt, should so long have remained unknown in the immediate neighborhood of so populous a center as Alexandria, seems little short of incredible.

The ruined city lies in the northeast corner of the Libyan desert, a few hours' ride by horse or camel from Beheig, an insignificant station on the railway which the Khedive is pushing steadily westward from Alexandria toward the Tripolitan frontier. The surrounding region is uninhabited save for scattered Bedouin camps, and lies far from any highway except that followed by the *hashish* smugglers, who lead their camels on dark nights past the ancient city on their way to Delingat, where the forbidden drug can be more safely disposed of than at Alexandria. The country round about is a bleak expanse of steppe, cultivated here and there with barley, the green surface often varied by low mounds, relics of ancient habitations. But in ancient times, when Nitria was one of the greatest centers of monasticism in Christendom and the home of thirty thousand monks, and the city of Saint Menas, with the tomb of the martyr and its healing springs, the most revered shrine in Africa, there must have been a considerable traffic from Alexandria by this route, for the city lay on the direct road to the Natron valley and its fifty monasteries, from which it is a ten hours' ride on horseback.

It is easy to conceive the magnificence of the ancient city. The churches, monasteries, and other buildings were all of marble, and the great basilica of the Emperor Arcadius must have been visible to the eager pilgrims for many hours before they reached the city gates. Abu Mina was exclusively a city of pilgrimage, an Egyptian Lourdes, and hither came vast throngs from every corner of Christendom to bathe in its healing waters and to pray at the tomb of the saint. The world-wide sanctity of the spot is evidenced by the fact that there is not a museum in Europe which does not possess one or more specimens of the terra-cotta flasks (*ampullæ*) in which the pilgrims brought back with them to their homes in Europe the holy water of Saint Menas.

The patron saint of Christian Egypt was a Greek officer in the armies of Rome, who, refusing to renounce Christianity, was martyred in Phrygia in the Diocletian persecution of 296 A.D. The body was taken to Alexandria and bound upon the back of a camel, which was turned loose in the desert to follow what course it chose. On the spot where the camel stopped, at some desert springs not far from the shores of Lake Mareotis, a grave was made and a shrine was subsequently built. Menas belonged to a patrician family, his father being the Roman governor of an African province, and his martyrdom consequently made considerable stir in the Christian world. No sooner was he buried than his tomb began to give forth miraculous powers. The water of the near-by spring was credited with marvelous properties for the curing of the halt, the lame, and the blind. A church was built there, and soon, owing to the lucrative pilgrim traffic, a town sprang up in the desert. The fame of the saint increased until, in the reign of Arcadius (395-408 A.D.) a basilica of noble proportions was erected by the emperor over the martyr's tomb. At this period there were probably at least five thousand permanent residents within the city walls, most of whom were priests, and this number must have been enormously increased during the times of pilgrimage. Then came the Arab conquest of Egypt, and the ensuing outbreak of Moslem fanaticism. The barbaric invaders swept the land with fire and sword. The priests and monks of Saint Menas met death on their own altars, although, curiously enough, the city and its shrine were but little injured by the invaders. The last extant account we have of the city was written by an unknown Arab traveler, who visited it probably in the tenth century. His description proves that for long after the Arab conquest, although the city was uninhabited, yet it was still intact, a place of magnificence even in decay, its churches and marble palaces surrounded even then by fruitful orchards and thriving vineyards.

The vines and fruit trees have all disappeared; the springs have long since dried up; the wonderful basilicas lie deep in the drifted sands, and for a thousand years not a single visitor save some wandering Bedouin has ever passed by the ruined temples and monasteries of the Lourdes of Christian Egypt. Although the feast of Saint Menas has always been religiously observed by the Orthodox, Jacobite, and Abyssinian churches, and the flasks of the holy water of the saint have been collected in all the museums of Europe, the mystery surrounding the actual site of the sacred city appeared to be as insoluble as that of the Garden of Eden. The discovery of the long-lost city is due to a German priest, Father C. M. Kaufmann, [illegible] to his cousin, Mr. C. F. Ewald Falls. They left Frankfort with the object of exploring the Christian remains in Cyrenaica, in the Tripolitan Hinterland. At the time of their arrival, however, Turkey was disputing with Italy regarding the harbor of Tripoli, and the Pasha of Bengasi refused them permission to conduct their explorations, on the plea that the lives of foreigners were unsafe, owing to the unsettled condition of the interior. The persevering archæologists had another scheme in reserve, however, which was to find the site of Karm Abu Mina, and so they turned their faces toward the Nile.

They knew from ancient manuscripts that the old city lay somewhere in the northeast corner of the Libyan desert in the neighborhood of Alexandria, but beyond that very indefinite knowledge, they were quite without data on which to base their investigations. They went as far south as the Wadi Natron and Moghara, and carefully explored all the old ruins in the district of Mariout. It was then well into the summer, and the sun blazed down remorselessly. Drinking water was difficult to obtain, and their supplies of food were running low. The Bedouin tribes were restless, and the lives of the intrepid Europeans more than once hung in the balance. After journeying for thirty days on camel-back, they halted one evening at a spot covered with ruins half buried in the sand, which the Bedouins called Boumna, and which was carefully avoided by the natives after nightfall, as it bore the reputation of being haunted by evil spirits. On strolling about the place, the attention of the travelers was attracted by quantities of old pottery scattered on the ground, fragments, apparently, of broken ampullæ. Only a single Bedouin tent was to be seen in the neighborhood. A boy came out of it on seeing the explorers, and showed them a perfect ampulla which he had found among the ruins, and which, to their astonishment and delight, was an image of Saint Menas.

Now at last it dawned upon them that their weary journeyings were at an end, and that they were standing on the very site of the sacred city—a city which was famed for its holiness when Paris was a pagan village and when London was a cluster of mud huts. No sooner had they begun to dig, than they discovered a large oven filled with numbers of lamps and a collection of beautiful ampullæ which are now in the Frankfort museum. The same day they found traces of a large apsidal building. The Arabic name of this lonely spot showed them in itself that they had at last reached their goal, for Boumna, or Karm a Boumna as the Arabs call it, was clearly a corruption of the ancient name of Karm Abu Mina.

The news of the discovery aroused great interest in the scientific circles of Europe, for it was at once recognized that a most valuable addition had been made to archæological science. The municipality of Frankfort decided to finance the work of excavation, which is now being carried on by several hundred Arab workmen under the direction of the discoverers, with that thoroughness of detail so typical of the German *savant*.

Four great basilicas have been entirely excavated. The crypt of Saint Menas, the great baptistry, together with many other sacred buildings, baths, cemeteries, and other appurtenances of a populous city, have been brought to light. Perhaps the most interesting find is that of the sanctuary of the patron saint of the Libyan Desert. It stands in the center of the city, in a lofty situation, and covers an area of nearly eight thousand square yards.

The basilica of the Emperor Arcadius was the most imposing of the many magnificent buildings of the sacred city. It was entirely covered with marble, both within and without, and its roof was supported by fifty gigantic columns. The bases and walls are still standing, and it requires but little imagination to reconstruct this remarkable building, which was 190 feet long and 166 feet broad in the transept. Numbers of exquisitely sculptured capitals strew the vicinity. The pavement of the building was of large squares of marble, and the interior still bears numerous traces of beautiful mosaics.

Under the apse of the basilica are three vaulted sepulchral chambers, before which stands the "bevra," a semicircular throne with steps. At the end of the basilica is the crypt of Saint Menas. It was here that the excavators had their hardest task, the crypt being covered with earth to a depth of more than forty feet.

The actual tomb of the saint was a wooden reliquary, exquisitely carved and similar in form to those in the Coptic monasteries of the Wadi Natron. Over the tomb was a marble relief of Saint Menas between adoring camels. The worshipers gazed down into the ornately decorated sepulcher from above through a large semicircular opening or well, the general arrangement being not unlike that of Napoleon's tomb at Les Invalides. The Menas basilica, under which the tomb lies, is the most ancient part of the sanctuary, the basilica of Arcadius being merely a prolongation of the original structure. The total length of the cathedral church was, therefore, in the neighborhood of four hundred feet. One of the features of this portion of the sanctuary is a holy well, three hundred feet deep, in which thousands of ampullæ were discovered, it being evidently from this source that the pilgrims filled their flasks with the holy water.

Nowhere in northern Africa are there such vast remains of ancient Christianity as here, the baptistry, which marks the center of the city, having been probably the finest monument of its kind in existence at that period. But of all the remarkable buildings of Abu Mina, none could compare in interest or grandeur with the great monastery or Koinobion of Saint Menas. It was the largest building of its kind in the ancient Christian world, and covered an area of ten and a half acres. It was larger than St. Peter's at Rome, and more than twice the size of the celebrated convent of St. Simeon Stylites near Aleppo in northern Syria.

Extensive excavations are now being made on this site, great progress having been made in spite of the difficult nature of the work. The pavements of more than fifty rooms, corridors, and halls have already been unearthed; two courts with large cisterns have been opened, and an amazing quantity of marble, porphyry, and fine granite has been found. It is conjectured that this profusion of marble came from the Serapeum, for in the reign of Theodosius, the father of Arcadius, the extirpation of paganism began, of which the destruction of the great temple of Serapis at Alexandria was one of the results.

Among other noteworthy buildings are the baths connected with the baptistry, in which the candidates for baptism were totally immersed. They were connected with elaborate waiting rooms, and supplied from a series of enormous reservoirs. In another part of the Koinobion a dining hall was discovered, which, from its great size and the beauty of its decoration, was probably reserved for the use of the high priests and distinguished guests. The roof of this hall was supported by columns, and the walls were covered with marble and porphyry. Here also was discovered a magnificent relief in white marble.

Over fifty huge cisterns or reservoirs have been discovered, and there are clear traces of irrigation canals for supplying the city with water from this source. On the occasions when it does rain at Boumna the downpour is torrential, and a single such shower would serve to fill up all the cisterns of the city. It is evident that the water supply was amply sufficient, for everywhere in the immediate vicinity of the city have been found traces of almond trees, olive orchards, and vineyards. These cisterns are still in a perfect state of preservation, and one of the memorable features of a visit to Boumna is the descent into them by means of rope ladders.

The tombs which have been discovered are also in a remarkable state of preservation, their general construction and the posture of the bodies which they contain bearing a marked resemblance to the catacombs in the vicinity of Rome. Fine specimens of ancient pottery, jewelry, and glass have been found in nearly all of them.

It is well known, from the accounts of contemporary writers, that the churches of Abu Mina were famed throughout Christendom for the profusion and beauty of the statues with which they were adorned. These statues were known to be in existence as late as the tenth century, having been described in detail by the Arab writer already mentioned; but whether they were destroyed by fanatical Moslems or whether they are still buried in the unexcavated portion of the great monastery, is a question which can only be solved by further excavations.

The exploitation of the remains of an earlier period of Egyptian civilization has had the effect of diverting public interest from that era which marked the founding of Christianity in the valley of the Nile; a neglect which the discovery of the city of Saint Menas may do much to remedy. The railway has yet to cross the desert to the sacred city; a rude mud dwelling and a cluster of black Bedouin tents provide the only shelter for miles around, and the wandering Arabs still make

the presence of the camel-mounted constabulary a necessity rather than a precaution; but one of these days, if the archæological promise which Abu Mina now holds forth is fulfilled, a visit to the ruins of the city of Saint Menas will be considered second only in importance to Gizeh, Memphis, and Sakkara.

USE OF DEAD TIMBER IN THE NATIONAL FORESTS.*

By E. R. HODSON, Forest Assistant.

A STUDY of the amount, location, and quality of fire-killed timber, and of the extent to which it is used, has been made by the Forest Service in a number of the national forests in the Southern Rocky Mountain region. This brought out very strikingly, first, that sound dead timber is valuable, and, second, that though widely used in some localities it is regarded as not worth using in others. The timber which was not being used was found to be fully as good as the other, and the only cause for rejecting it proved to be ignorance of its true value.

There are three classes of dead timber: (1) Fire-killed timber, (2) timber killed by insects, and (3) timber killed by such other causes as drying out or lightning.

Fire-killed timber, which is the best, forms by far the largest part of the dead timber in the national forests, and is found throughout them. Insect-killed timber, though widely scattered, is usually restricted to small areas. In some localities, however, particularly in the Black Hills, South Dakota, there are many millions of feet of such timber. Dead timber of the third class is mainly met with in single trees or small groups, but the aggregate amount of it is large. Unless otherwise stated, the dead timber hereafter discussed is fire-killed timber.

The area covered by the study was approximately 13,000,000 acres. On this area there is estimated to be 500,000,000 feet B. M. of merchantable dead timber, or about 4 per cent of the total merchantable stumpage. About 50 per cent of this, especially of the larger dimensions, is fit for saw lumber, and all of it can be utilized in the round. There is also a large amount of cordwood, suitable only for fuel, charcoal, and similar purposes.

The principal defect of fire-killed timber is check. This appears soon after the death of the tree, and apparently does not greatly increase later. Timber above 9,000 feet elevation is not affected by decay for many years. Such timber has been used after more than fifty years have elapsed since burning, and vast quantities of timber killed by fire twenty or thirty years ago are entirely free from decay.

Fire-killed timber should be barked soon after it is killed, in order to prevent decay of the surface. If the bark has been left on, the sapwood is somewhat decayed. Lodgepole pine and Engelmann spruce have about the same durability; after twenty-five years about 50 per cent is usually standing, and the fallen timber, if not flat on the ground, lasts five or six years. Balsam lasts about one-third as long. Standing Douglas fir lasts almost indefinitely, and even when flat on the ground decays but slowly. Yellow pine decays more rapidly, since it occurs mainly below an elevation of 9,000 feet. On the other hand, on account of the openness of its stand, it is rarely killed by fire.

In many places it is the popular opinion that dead timber is very much weaker than seasoned green timber. It is even held that timber which has been dead a number of years is weaker than green timber, and that the longer it stands the weaker it becomes. These views are quite wrong. By actual test it has been shown that sound timber is almost as strong as seasoned green timber and much stronger than green timber before seasoning.

Seasoning greatly adds to the strength of timber, so that in order to make the comparison a fair one the green and the dead timber must be brought to the same condition of seasoning. When this is done, the tests indicate that dead white fir is about nine-tenths as strong as green white fir which has been seasoned and about twice as strong as green timber freshly cut.

Since the principal defect of dead timber is check, it has been used largely in the round for mine timbers, coal props, telephone poles, railroad ties, and fence posts. The better grades are also used for dimension stock, which is not seriously affected by the shallow checks found in these grades. It is not much used for inch stuff, however, except as cut-up stock, because of frequent cross checks.

The chief use to which dead timber is now put is for mine timbers. For this purpose it is even better suited than green timber, because it is perfectly seasoned and is light.

It is estimated that the mines of Leadville, Col., use each month 350,000 feet B. M. of dead timber. There are also many other large mining camps that use it in wholesale quantities. In these camps it is decidedly preferred to green timber.

For fifteen years dead timber has been used for railroad ties in the Pike's Peak National Forest, where it has proved entirely satisfactory. Wherever dead timber is located sufficiently near the track, it is readily sold for ties. Douglas fir, limber pine, yellow pine, range pine, and, occasionally, Engelmann spruce, are the species used.

Dead timber is eminently suited for making boxes and crates, because it is odorless and is perfectly seasoned. A package made from it does not shrink or warp, but remains as tight as when first made. Since dead timber, when sawed, is largely cut-up stock, it should find a wide use for such purposes.

In smaller quantities dead timber has been used for telephone and telegraph poles, dimension stuff, and fence posts. In fact, it has been used for everything for which green timber is used, except thin sawed lumber, and there is no reason why it should not be used for this to a considerable extent also. Narrow widths of the best material, not damaged by checking, could be worked up into flooring and ceiling, and it could be used for second-grade lumber, which would not be seriously affected by a certain amount of checking.

The use of dead timber results in a double economy—the prevention of waste and a saving of more valuable timber for better uses.

It is past question that sound dead timber, particularly when fire-killed, has decided value and keeps this value for a considerable length of time. Decay does not readily affect it. The strength is not impaired by standing in the dead condition. Some of it is checked, to be sure, but even the best sound green timber is sometimes checked very seriously in seasoning.

Sound dead timber has this especially in its favor: It is perfectly seasoned, and is therefore easily handled and cheap to ship.

Dead timber, moreover, is in an excellent condition for preservative treatment, as the moisture has evaporated from the wood so there is no watery sap to act as a mechanical barrier to the entrance of the preservative. Green or seasoned timber must be piled for several weeks before it is in a proper condition for treatment, or else it has to be subjected to various processes to season it artificially. This artificial seasoning is expensive and is liable to reduce the strength of the timber; therefore sound dead timber is really more valuable for preservative purposes than green is. It also happens that most dead timber in the West has an open, porous structure, and can be treated by a simple and inexpensive process without the use of complicated apparatus required by other kinds of wood.

* Abstracted from a bulletin issued by the United States Department of Agriculture.

THE AFRICAN OSTRICH INDUSTRY.

A PROFITABLE SOUTH AFRICAN MONOPOLY.

THE following particulars are from a report furnished by Consul R. B. Mosher, of Port Elizabeth. Ostrich farming has long been an important industry in South Africa.

Young birds were first inclosed in 1857, and first hatched in incubators in 1869. At the last census the number of domesticated ostriches in Cape Colony was 358,370, valued at from $12 to $2,450 each.

The farms combine ostriches and cattle in wooded districts and ostriches and sheep where grass grows, and are very profitable. The number of employees seldom exceeds thirty per farm. The breeding camps, each of about 25 acres, inclosed by wire fences 5 feet high (the ostrich cannot jump), contain usually one cock and two hens. The cock bird is always dangerous, but has little sense and can be easily warded off by means of a long thorn bush. If a pronged stick be pressed against his throat, he will press forward instead of retreating, and can thus be led about.

Breeding is usually done by incubation. The birds are fed daily and are not disturbed in any way. When born they are the size of a chicken, but grow rapidly, and in six months are nearly as large as the parents. Chicks are placed in camps of about 100 acres, where they are cared for by a native herder and fed on lucerne (green alfalfa) and other succulent plants, corn, pebbles, and broken bone, and given plenty of water. Old birds are given the same kind of food. Their principal enemy is the jackal, which is destroyed by poison. Besides jackals, the chief causes of loss are injuries to the parent birds, cold, dry, and irregular feeding, wireworm, tapeworm, and ostrich mite. A pair of birds breeds once a year and hatches about twenty eggs; but in Africa a trio of birds has produced in a single year 188 eggs, from which 133 young were raised. When fully grown they are allowed to run in camps of 2,000 to 3,000 acres, some 20 acres being allowed for each bird.

VALUE OF THE FEATHERS.

The wing feathers of the male bird are called "whites" and of the female are called "femina"; the tail feathers of both birds are called "boos"; blacks and drabs are the two rows of wing and body feathers of the male and female, respectively. The feathers are cut or plucked once or twice a year, yielding from $7.50 for low-grade birds to $130 for good birds per annum, the highest authenticated yield for a bird being $150. The plumes from the wings and tail of the full-grown male bird are the most valuable. There is a marked difference in the feathers from the several districts of Cape Colony. The Oudtshoorn feather is of abnormal length, reaching 29½ inches or more, and lacks the compactness and the richness of the flue possessed by the Middleburg and Bedford types. The Graaff-Reinet specimen is 23½ inches, while the Middleburg and Bedford feathers measure 22½ inches and 20¾ inches, respectively, and are fine types of a good, well-bred, compact feather, shapely and flawless, with a thin quill carrying a well-developed strong flue of fine quality.

Feathers of the wild bird are oily and greasy, with a long quill. The efforts of South African breeders are directed to a system of selection in breeding, by which the size of the quill is reduced and the richness of the flue is increased. The Ostrich Stud Book is of great assistance in producing this result.

Bars are a serious defect in ostrich feathers to which general attention is now being given. They are not found in the feathers of wild birds, and are believed by the government expert here not to be primarily due to the presence of mites or ostrich flies, but to be the result of too much interbreeding, which produces a low nutritive condition. Good feeding will reduce the defect, but probably not eliminate it. A more liberal interchange of birds is believed to be the remedy, but the whole subject is now under investigation by the Rhodes University College at Grahamstown.

There are a few birds in Natal, and in 1893 Argentina, Australia, and California obtained a few, but the industry is comparatively inconsiderable outside of Cape Colony.

Brands are registered and protected; stray domesticated birds may not be killed, injured, or kept by any person other than the owner under penalty in damages; dogs found in inclosures of domesticated ostriches may be destroyed; buyers of feathers must have a license of $25 annually, keep a special book, and produce it under penalty of $500, or not over three months' imprisonment.

Wild birds may not be caught, captured, hunted, or shot, and wild ostrich eggs may not be taken and removed from any Crown lands without a license, under penalty of $100 fine or six months' imprisonment, and the same penalty attaches to capturing, hunting, or wounding wild birds, or interfering with or disturbing their eggs, upon private lands, without the owner's consent. The governor may proclaim a close season in any division against killing, wounding, or shooting any wild ostrich, with or without a license, when it is so resolved by the divisional council. A government bill has just passed the Cape Parliament which prohibits the exportation of ostriches or their eggs. There is also now before the Parliament a bill for the "repression of thefts of ostrich feathers" which provides for the registration of ostriches ten months old or more, the licensing of feather buyers, with heavy penalties for false registry, contravening the regulations for feather buying, etc.

The great boom in ostriches came in 1880. The usual price of a pair of birds was then $975, and th sometimes sold for $4,875. The exports for Cape Colony in 1882 were 253,954 pounds of feathers, valued at $5,323,897, or an average of $21 per pound. In 1905 exports were 471,027 pounds, valued at $5,136,998, showing an increase in weight of 217,073 pounds, and a decrease in value of $183,963, which is accounted for by the large quantity of inferior feathers now produced. Many of these poor feathers are sent to Germany, where they are made up into bons, feathers for dolls' hats, etc. The exports for the year 1906 amounted to 547,697 pounds, valued at $6,842,878. Of the $3,407,533 worth of feather exports from Port Elizabeth during 1906, $825,931 worth went to the United States, made up principally of the highest grades. The shipments to America still further increased in 1907, the amount reaching $732,760 for the first six months.

Silver Leaf, Imitation, Alloy of Tin and Zinc.—Harder than tin, softer than zinc: 11 parts by weight of tin, 1 part of zinc.

FISHES THAT HATCH THEIR EGGS IN THEIR MOUTHS.

BY DR. J. PELLEGRIN.

We are accustomed to regard the cold-blooded yet ferocious and cannibal fish as an animal which takes no care whatever of its offspring. This is true of most sea fishes and also of the majority of the fresh-water fishes of the temperate zone. In many species of these two classes each adult female lays hundreds of thousands, or even millions, of eggs annually. Although the eggs and the young fish, or fry, are the prey of numerous enemies, so that comparatively few of the immense brood succeed even in leaving the shell and only an infinitesimal proportion arrives at maturity, the number of survivors, though relatively small, is absolutely large enough to assure the perpetuation of the species unless man devotes his ingenuity to its extermination—as he has done with a fair measure of success in the case of the shad, the salmon and other valuable food fishes.

Almost the only fish of our streams and lakes that takes any care of its young is the stickleback, of which the polygamous male builds a sort of nest or trap, induces a number of females to lay their eggs therein and jealously guards the eggs until they hatch and the fry until they become able to take care of themselves, the emancipated females having washed their fins of domestic affairs as soon as they have laid their eggs. The sea bass and the goby are also nest builders.

In the tropics, however, and especially in Brazil, many fresh-water fishes produce comparatively few and large eggs and adopt various methods of bringing nearly all the small brood to maternity. Some species are ovo-viviparous, the eggs being hatched within the body of the mother and the young brought forth alive. In others the eggs are attached to the abdomen of the mother, where they can hatch in security.

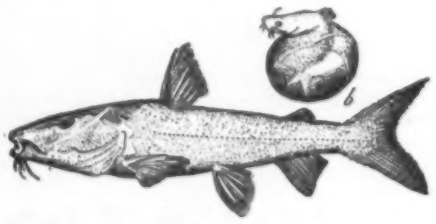


Fig. 1.

a. Yucatan cat-fish. *b*. Its egg and embryo enlarged.

This method, exceptional in fishes, is adopted regularly by crabs and many other crustaceans. Still other species are nest-builders, like the stickleback.

But the most curious mode of preserving the eggs, and consequently the species, from destruction is buccal incubation or, in plain English, hatching in the mouth. After the eggs have been laid and fertilized they are placed in the mouth of one of the parents, where they find conditions very favorable for incubation, as they are protected from marauders of every kind and are bathed in an ever-flowing current of water which supplies the air required for their life and development. This singular manifestation of parental care does not cease when the eggs hatch. The young fry accompany their parent and take refuge in his or her mouth at the approach of danger. How the parent satisfies its hunger—ravenous in most fishes—is a mystery. In some cases, no doubt, the eggs, like the fry, are not kept permanently in the mouth but are only taken into it when danger threatens. But as a general rule the eggs are pressed together in a compact mass which so completely fills the mouth that it is difficult to understand how it can be removed and replaced. In such cases the parent fish must fast during the entire period of incubation, sustaining its life by the consumption of fat previously stored up for this purpose in various parts of its body.

In some species the father, in others the mother, performs this act of devotion, and sometimes, though rarely, both parents co-operate in hatching the eggs and rearing the young.

Buccal incubation is practised most extensively by fishes of the siluroid or cat-fish family, especially the East Indian and South American species of Arius. Usually the care of the eggs devolves on the male, but in one species the female occasionally takes charge of them. The eggs are few in number and very large. The mouth of an Arius little more than six inches long, caught in Guiana, was found completely filled and distended by ten eggs more than one-third of an inch in diameter, and eggs of twice this diameter have been found in the mouths of large specimens, three feet or more in length.

Conspicuous among other fishes which are known or alleged to practise buccal incubation are the electric siluroid of the Nile (which must not be confounded either with the gymnotus or electric eel or with the torpedo or electric ray) and the great pirarucu or arapaima of the Amazon, the largest of American fresh water fishes, with an average length of eight feet. In the latter species the female hatches the eggs and rears the young. This is the general rule in the Old World, but in most American species these duties are performed by the male parent. Thus do the emancipation and exaltation of American womanhood find justification in ichthyology!

Buccal incubation is very general among a family

Fig. 2.—THE ARAPAIMA.

of fishes which are akin to the perch and inhabit African and American rivers. One of the American species, belonging to the genus Geophagus, has been domesticated and bred in aquariums where the spectacle of the devoted and presumably proud and happy father surrounded by his numerous brood, like a hen in the midst of her chicks, is curious and pleasing to contemplate.

One of the earliest known of fishes, the bolti (Tilapia), which is found pictured on Egyptian monuments, may on the other hand be cited as an example of maternal devotion. From one hundred to two hundred eggs have been found in the mouth of a female bolti, but never one in the mouth of a male. Buccal incubation is comparatively rare among ocean fishes, but it occurs in a few species.

On the whole, it appears that this curious practice is not very uncommon among fishes. Hence when we hear or read of fishes being caught with eggs or fry of their own species in their mouths we should neither ascribe the authorship of the stories to the nature faker section of the Ananias club or liken the fishes to Saturn devouring his offspring. They may be devoted parents and strenuous opponents of race suicide.—Translated for the Scientific American Supplement from La Science au XXme Siècle.

THE PINEAL EYE, THE PINEAL GLAND, AND THE PITUITARY BODY.

The pineal gland, or epiphysis, and the pituitary body, or hypophysis, are two small appendages of the brain which, after being long neglected by anatomists and physiologists, have lately attracted a great deal of attention. Although they have been studied chiefly in the human subject and from a medical point of view, the glands are not peculiar to man but are found in all mammals.

The human pineal gland is a small grayish body situated in the median plane of the head above and behind the middle ventricle of the brain. The gland

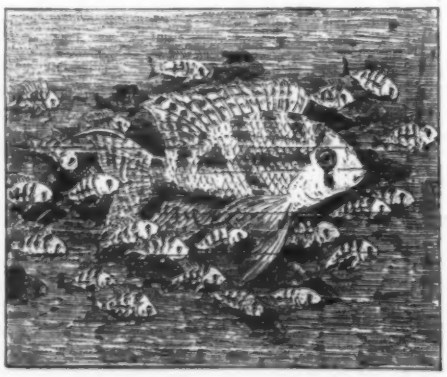


Fig. 3.—A GEOPHAGUS SURROUNDED BY ITS YOUNG.

is about as big as a pea, its average length being rather less than 1/3 inch and its average breadth 1/5 inch. Its weight is only 3 or 4 grains Troy. The name pineal is derived from the shape of the gland, which resembles that of a pineapple. The little gland is inclosed in a sack that is well supplied with blood vessels, and it is divided into a great number of compartments which are filled with a tissue of pointed cells similar to the ordinary basal tissue of nervous centers. The pineal gland also contains particles of carbonate of lime and phosphate of magnesia, but it is destitute of special nerve cells and fibers. The absence of true nervous elements and the presence of mineral concretions indicate that the pineal gland is a degenerated organ, nearly or quite incapable of functional activity.

More important rôles have sometimes been attributed to this diminutive gland. Descartes made it the seat of the soul, and Magendie regarded it as a sort of plug designed to control the circulation of the fluids of the brain by damming the channel called the aqueduct of Sylvius, which connects the third or middle lobe of the brain with the fourth lobe. Others have seen in it merely a blood or lymph reservoir.

At present the prevailing opinion, based on comparative anatomy, is that the gland is the degenerate remnant of an organ which, in remote ancestors of the human species, was well developed and of great importance, namely, the third or pineal eye. Apart from all hypothesis, it is known that some of the lower vertebrates now existing possess a more or less rudimentary third eye, the nerves of which originate in the pineal gland.

This pineal eye is most clearly evident in lizards, in which the pineal gland forms the base of a long nerve trunk, directed upward and forward, which passes through a hole in the skull and terminates in a vesicle under the skin. This vesicle contains all the essential elements of an organ of vision. A central cavity filled with liquid is bounded in front by a crystalline lens and at the sides and back by a retina containing rod-shaped cells, and the retina is surrounded in turn by lines of pigment which represent the remnants of the choroid or pigmented coat of the eye.

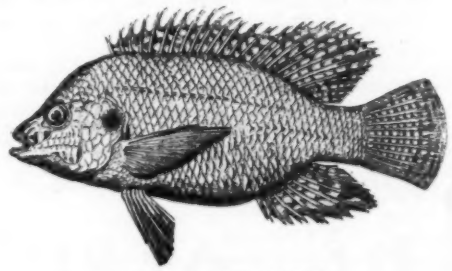


Fig. 4.—THE BOLTI.

The pineal eye appears to possess the power of sight in only two species of lizard: the *Lacerta ocellata* of Southern Europe, and an Australian species of *Hatteria*. In all other species it is incapable of vision and is, according to the current view, a degenerated organ which is somewhat less completely atrophied than the pineal gland of man.

M. de Cyon, however, has been led by his recent researches communicated to the Académie des Sciences (April 22, 1907) to return to Magendie's theory and regard the pineal gland as a mechanical regulator of the flow of cerebral fluid.

The human pituitary body or gland has nearly the shape and size of a bean. Its transverse or greatest diameter is rather more than ½ inch, its other dimensions ¼ inch and 1/3 inch, and its weight 5 or 6 grains troy. The name pituitary is derived from a Latin word meaning phlegm, for early anatomists supposed that the little gland collected phlegm from the brain and discharged it into the throat. Although the pituitary body is inside the skull and is connected with the brain, it is not an integral part of the latter. It develops, in the embryo, in a region which ultimately becomes the back of the mouth, and the pouch thus formed remains open through life in some of the lower vertebrates. In the lancelet (*Amphioxus*) the pouch is simply a wide tube opening into the mouth, as it is in the human embryo at the sixth week of development. In some cartilaginous fishes the gland is connected with the mouth by a very narrow tube, but in all mammals the communication with the mouth is interrupted and the gland isolated at some period before birth.

Until recently it was a matter of doubt whether the pituitary gland exercised any useful function, but that it does so is now well known, for its destruction by accident or disease is followed by apathy, muscular weakness, loss of the power of co-ordination of movements, muscular spasms, and lowering of the bodily temperature, terminating in death. An infusion of the pituitary gland of a dog, injected into another dog, causes an immediate rise of arterial pressure. This result indicates that the gland secretes a substance that affects the circulation and, as a matter of fact, two such substances have been isolated, of which one

increases the force of the heart's beat, while the other acts upon the vaso-motor nerves which control blood supply. Within the past year Gemelli has discovered differences of structure between the pituitary glands of active and those of hibernating marmots. Hence the pituitary gland is not an obsolete or rudimentary organ, but an active gland of internal secretion—a fact which is further corroborated by Pettit's study of the well developed pituitary gland of a rare deep-sea fish (*Centroscymnus*) specimens of which were obtained in one of the exploring cruises of the Prince of Monaco.

The secretion of the gland powerfully stimulates growth, especially of bony tissue. The singular disease called acromegaly, which is characterized by an exaggerated development of the extremities, is commonly associated with enlargement of the pituitary gland. This enlargement can be detected by Röntgen rays and also by disturbances of vision caused by the pressure of the gland on the optic nerve as well as by post-mortem examination. Many giants, likewise, have enlarged pituitary glands.

Other glands of internal secretion, however, are affected in acromegaly, and there are cases in which the pituitary is not affected while, on the other hand, enlargement of the pituitary gland may exist without acromegaly. Hence Gemelli, Guerrini, Andriezen, and others regard the pituitary gland as essentially an antitoxic organ, like the suprarenal, thyroid, and parathyroid glands. In other words, its chief function is to destroy or neutralize toxins or poisons formed in the body (auto-intoxication) or introduced from without. This theory is confirmed by the increased activity of the gland which follows ligature of the ureters or bile duct or the injection of poisons or bacterial toxins. According to Andriezen, the gland also exercises a general tonic effect on the nervous system.

M. de Cyon, however, regards the pituitary, like the pineal gland, as a regulator of the blood pressure in the brain. His recent researches lead him to believe that the pituitary gland averts cerebral congestion by controlling a number of safety valves, of which the thyroid bodies are the most important.—Adapted from Cosmos and La Science au XXme Siècle.

THE TEMPERATURE OF THE SUN.

EXPERIMENTS ON MONT BLANC.

BY A. MILLOCHAU, ASSISTANT ASTRONOMER AT THE MEUDON OBSERVATORY.

THE solar radiation which maintains life upon the earth produces on our senses impressions comparable with the effects of artificial sources of heat and light. Hence astronomers and physicists have been led to seek a measure of the calorific power of the sun by

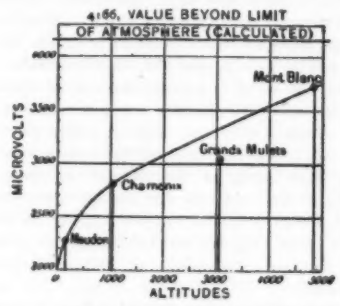


FIG. 1.—CURVE OF ATMOSPHERIC ABSORPTION AT VARIOUS ALTITUDES.

comparing the heating effect of its rays with that of a source of heat whose intensity can be measured directly.

Newton, who may be called one of the forerunners of physical astronomy, seems to have been the first to attempt to investigate the temperature of the sun. By comparing the indications of a thermometer in the sun and in the shade he obtained a rough measure of the thermal intensity of the sun's rays.

In 1774 De Saussure constructed an instrument based on the first principles of actinometry. It consisted of a box made of cork, blackened inside and covered with glass on the side which was turned toward the sun. The temperature of the interior of the box was measured by a thermometer.

Sir John Herschel inaugurated the dynamic method of actinometry by measuring the rise of temperature of a thermometer exposed to the sun's rays for a given time, together with the rate of cooling of the same thermometer in the shade, before and after insolation.

Pouillet (1837) was one of the most diligent students of actinometry. He invented two pyrheliometers. One of these was similar to De Saussure's apparatus except that the inclosure was surrounded by double walls, entirely opaque, and the rays entered through a small hole. The other pyrheliometer was a sort of calorimeter of silver, filled with water, the temperature of which was measured by a thermometer.

In 1845, Henry compared the intensity of radiation of various points of the solar disk, including

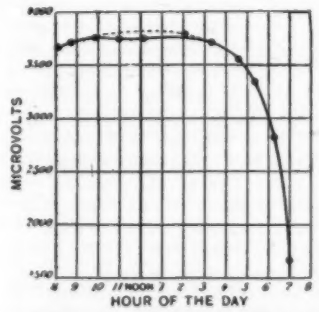


FIG. 2.—CURVE SHOWING VARIATION OF RADIATION RECEIVED ON MONT BLANC AUGUST 2, 1906.

the sun spots, by projecting a magnified image of the sun on a screen pierced by a small hole and receiving on a thermo-electric pile the pencil of rays that passed through the hole.

These experiments were repeated by later investigators, including Secchi and Vogel. Wilson and Gray, in 1894, employed the same method but substituted a Boys radio-micrometer for the thermopile.

Finally, Violle, Crova, and Angström invented the actinometers which are now generally employed.

In general terms the methods of actinometry may be classed in two groups:

1. The statical method, which consists in taking the reading of a thermometer exposed to the sun's rays.

2. The dynamical or calorimetric method, which consists in measuring the quantity of heat received by a black body of known area exposed to the sun's rays for a measured time.

The name solar constant has been given to the number of calories absorbed by one cubic centimeter of water through a blackened surface of one square centimeter exposed to the sun's rays for one minute, a correction being made for absorption of heat by the atmosphere.

The name solar constant is ill chosen, for it is very probable that this quantity is not constant. The study of its variations is one of the important items of the present international programme of solar physics.

Another question suggests itself. The effect produced on the earth by the sun being known, is it possible to deduce the temperature of the sun, that is to

FIG. 5.—SETTING UP THE INSTRUMENTS AT THE JANSSEN OBSERVATORY ON MONT BLANC.

say, the reading of a thermometer plunged into the sun's mass?

This temperature cannot be computed without the aid of hypotheses, and the result of the calculation is not the temperature of the sun but that of a body which in physical conditions determined by the hypothesis employed, would produce, if substituted for the sun, the observed thermal effect of the latter.

In physics a black body is defined as a body that emits and absorbs the maximum amount of radiation at any given temperature. An inclosed space, the interior of an oven for example, is a theoretically perfect black body, and the radiations projected through a small hole in the wall of the oven are identical with the radiations emitted by a perfectly black body at the temperature of the oven. If the temperature is high this black body becomes luminous, hence C. E. Guillaume has proposed to replace the equivocal term black body by the more logical designation of integral radiator.

Stefan has proved that the energy of the radiation emitted by such a radiator is proportional to the fourth power of the absolute temperature, that is, the temperature reckoned from the absolute zero, —273 deg. C. or —459 deg. F. This law has been verified for all temperatures that can be attained.

By applying Stefan's law to the values of the solar constant furnished by experiment it is possible to determine the temperature of an integral radiator which, if substituted for the sun, would produce the observed thermal effect.

The following values of the solar constant have been given by various writers:

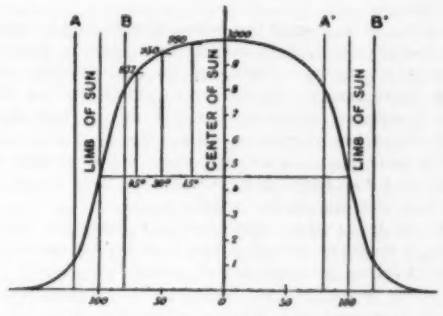


FIG. 3.—CURVE OF RADIATION OF VARIOUS PARTS OF THE SUN (1906).

Pouillet	1837	1.793
O'Hagen	1863	1.9
Forbes	1842	2.82
Violle	1875	2.28
		2.37
Langley	1884	3.068
Savelief	1889	3.47
Pertner	1889	3.05
		3.28
Angström	1890	4.00
Hansky	1905	3.29

These numbers vary from 1.8 to 4.

The temperature of the equivalent integral radiator, as defined above, is found by Stefan's law to be 5,600 deg. C. for the lowest value of the solar constant, 1.8, and 7,000 deg. C. for the highest value, 4. The most delicate point in the determination of the solar constant is the estimation of the absorption of radiant heat by the earth's atmosphere, for the absorption varies incessantly and is closely dependent on the hygrometric state of the air. Useful results can be obtained only from observations at great altitudes.

In 1894, Wilson and Gray attempted to measure the temperature of the sun by the statical method by direct comparison of the readings of a thermometer when exposed to the sun's rays and to the radiation of a strip of platinum heated by an electric current. In 1902, Wilson continued the experiments, substituting an oven heated by gas for the strip of platinum. Employing Rosetti's tables for the calculation

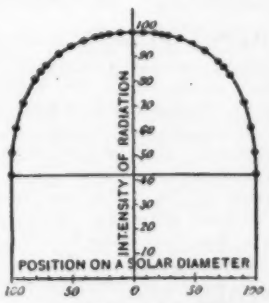


FIG. 4.—CURVE OF RADIATION OF VARIOUS PARTS OF THE SUN, CONSTRUCTED FROM WILSON'S OBSERVATIONS (1894).

of the terrestrial atmospheric absorption, Wilson, in 1902, announced 5,573 deg. C. as the temperature of an integral radiator which, if substituted for the sun, would produce the same general effect; 6,200 deg. C. for a similar radiator surrounded by an atmosphere which would cause by absorption the observed differ-

ence between the effects of the edge and the center of the solar disk; and 6,863 deg. C. on the assumption that the total loss by absorption in the solar atmosphere is correctly expressed by the values obtained by Wilson and Rambaud.

In 1902, M. Féry, in the course of a study of the emissive powers of various substances, devised a new pyrometer which he soon afterward applied, commercially, to the measurement of the temperatures of furnaces.

This pyrometer is based on the following principle: If the rays emitted by an integral radiator maintained at a constant temperature are concentrated upon the junction of a thermo-electric couple of small mass, in such a manner that the radiator as seen from the junction always subtends the same angle, the difference of potential of the terminals of the couple remains the same for all distances of the radiator, so long as its image covers the junction.

This difference of potential, which can be measured with a galvanometer, is connected with the temperature of the radiator by Stefan's law, this temperature being equal to the fourth root of the difference of potential, multiplied by a constant factor which depends on the construction of the instrument. This constant is determined by directing the instrument to an electric oven or other integral radiator, the temperature of which can be measured by an independent method.

For the projection of the image of the radiator upon the thermopile M. Féry employed, at first, a lens of fluorine, a substance which absorbs only rays of very great wave length. He afterward substituted for the lens a silvered or gilded concave mirror and thus constructed his pyrometric telescope. Then it occurred to him that such an instrument could be used in measuring the temperature of the sun, and he asked me to assist him in the measurement.

We designed and constructed the necessary apparatus, a modified reflecting telescope with a mirror of about 4 inches diameter and 32 inches focal length. In the focal plane of the mirror is a thermo-electric couple composed of a wire of constantan and one of iron arranged like the cross wires of a telescope. The junction is covered by a very light and small blackened disk. The ends of the wires are attached, by cold welding, to two insulated rings of copper which are connected by flexible copper wires to a galvanometer.

Behind the thermopile, which also serves as a reticle, is a bent eyepiece by means of which the telescope can be pointed so as to bring the thermo-electric junction to any part of the solar image. The galvanometer gives the electromotive force directly to about 1/100 millivolt. As the thermopile operates under the best conditions when the elevation of temperature of the junction is 25 deg. C., the mouth of the telescope is covered by a diaphragm with an open sector of 90 degrees, in front of which a graduated disk having a similar open sector can be rotated so as to vary the effective aperture.

The Mont Blanc Society and its president, Prof. Janssen, having kindly put their observatory and equipment at our disposal, we decided upon the following programme:

1. A study of the apparent temperature of the center of the solar image at various hours of the day and elevations above sea level, for the purpose of determining the effect of the earth's atmosphere. The stations selected and their elevations are: Meudon, 150 meters (492 feet); Chamonix, 1,000 meters (3,280 feet); Les Grands Mulets, 3,050 meters (10,000 feet); and the Janssen observatory at the summit of Mont Blanc, 4,810 meters (15,775 feet).

2. A study of the thermal emission of various parts of the sun's surface. In this investigation we adopted the chronometric method which Janssen described in 1868 and employed in the observation of the solar protuberances.

In this method the telescope is fixed and readings of the galvanometer are taken at regular intervals as the solar image moves across the reticle. A curve is then traced by taking the successive positions of the reticle on the image as abscissas, and the corresponding galvanometer deflections as ordinates.

In July, August, and September series of observations were made at Chamonix, Les Grands Mulets, the summit of Mont Blanc and, finally, at Meudon. The instrument was then taken to the physical laboratory and standardized by pointing the telescope to an electric oven heated, by platinum resistance coils, to 1,673 deg. C. absolute temperature.

The corrected constant of the instrument was found to be 705. That is to say, the absolute temperature T of an integral radiator which causes a galvanometer deflection of 3 microvolts with the full opening of the diaphragm, may be computed according to Stefan's law by the equation: $T = 705\sqrt[4]{\delta}$. The value 715 was obtained for the constant by substituting for the electric oven the crater of an electric arc of an assumed temperature of 3,773 deg. C.

The mean deflections, in microvolts, obtained at midday at the various stations for the center of the sun were: Meudon, 2,250; Chamonix, 2,830; Grands Mulets, 3,050; the summit, 3,700.

The effect of the atmosphere can be estimated approximately from the very regular curve of observations made at the summit at different hours on August 2, when the air was remarkably clear. (Fig. 2.)

If the air above the observer undergoes no change during a series of observations the intensity of radiation outside of the atmosphere can be calculated by Bonguer's formula: $I = I_0 e^{-kx}$ in which I denotes the observed intensity, I_0 the intensity outside of the atmosphere, k a constant coefficient of absorption and x the length of path through the atmosphere. If x is taken as the vertical depth of the homogeneous atmosphere this formula applies to the case in which the sun is in the zenith. If the zenith distance of the sun is a and the curvature of the earth is neglected the formula becomes $I_a = I_0\, e^{-\frac{kx}{\cos a}}$. Hence by combining observations taken at any two zenith distances $k\,x$ can be eliminated and I_0 determined.

The curve of observations of August 2 gives:

	Hour Angle of Sun. Deg.	Zenith Distance of Sun. Deg.	Min.	Radiation Expressed in Microvolts.
(1)	30	36	20	3,800
(2)	45	45	48	3,750
(3)	60	56	12	3,650
(4)	75	66	58	3,452

Combining these results in pairs we obtain the following values for I_0, the radiation outside of the atmosphere:

From (1) and (2)	4,149
From (1) and (3)	4,162
From (1) and (4)	4,163
From (2) and (3)	4,172
From (2) and (4)	4,168
From (3) and (4)	4,166

The first of these values is otained from two points near the vertex of the curve and is made uncertain by the depression shown in Fig. 2. The mean of the other five values, 4,166 microvolts, may be taken as the measure of solar radiation outside of the atmosphere on that day.

The effective temperature of the center of the solar disk, or the temperature of the equivalent integral radiator is, therefore, $T = 705\ \sqrt[4]{4{,}166} = 5{,}663$ deg. C. absolute, or 5,390 deg. C. (9,734 deg. F.) on the ordinary scale. The observations made at the lower stations prove, as most investigators have already pointed out, that the coefficient of absorption varies from hour to hour so that this method of calculation cannot be employed.

Observations from a still greater elevation, from a balloon, for example, would serve to test the results obtained at the summit of Mont Blanc, which are certainly more trustworthy than those obtained at lower levels.

The operation of standardizing the instrument was facilitated by covering the thermo-electric junction with a small disk which increased the sensitiveness of the pile. The advancing, as well as the receding limb of the sun occupied 13 seconds in crossing this disk—a fact which must be taken into consideration in comparing the radiation of the limb with that of the center. In future experiments we shall use as small a junction as possible.

Nevertheless, if the series of observations made by the chronometric method at the various stations are plotted on the same scale, taking the central radiation as 1,000 microvolts, all the curves coincide and give the curve shown in Fig. 3. This coincidence proves that the absorption by the earth's atmosphere is proportional to the intensity of radiation. Within the limits between which the junction is always completely covered by the solar image the curve is identical with one constructed in a similar manner from the results published by Wilson in 1894 (Fig. 4). The same conditions, therefore, governed the solar radiation in 1894 and 1906.

Admitting the hypothesis, which appears very probable in the present state of our knowledge, that the sun is composed of a hot nucleus, acting like an integral radiator, and an atmospheric envelope which absorbs heat, we may attempt to form an approximate estimate of the effect of this solar atmosphere by the method which we applied to the earth's atmosphere.

From the curve of radiation of various points of the sun (Fig. 3) we find that if radiation is 1,000 at the center it is 950 at a point 30 degrees from the center and 877 at a point 45 degrees from the center. These figures, combined in pairs, give 1,393, 1,372, and 1,358, or a mean value of 1,374, for I_0, which in this case denotes the radiation of the sun's nucleus undiminished by the absorbing effect of the solar atmosphere, when the radiation which traverses that atmosphere is denoted by 1,000.

Hence the effective internal temperature of the sun is obtained by multiplying the effective surface temperature, 5,663 deg. C. absolute, by the fourth root of 1.374. The result is 6,130 deg. C. absolute, corresponding to 5,857 deg. C. (10,575 deg. F.) on the ordinary scale.

As the form of the curve of solar absorption is independent of the absorption by the earth's atmosphere the loss by solar absorption, amounting to 37 per cent, can be calculated from observations at any level, and the pyrheliometric telescope affords a simple means of studying possible variations in the effect of the solar atmosphere.

If, as appears probable, the great interior mass of the sun cools so slowly that its temperature remains sensibly constant, variations in the absorbing effect of the solar atmosphere must be the sole cause of variations in the intensity of solar radiation. This hypothesis, perhaps, may be proved or disproved by a series of observations at very great altitudes.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

HOW OBSERVATIONS OF MARS ARE MADE AT FLAGSTAFF.*

By G. R. AGASSIZ.

THE writer has lately enjoyed the great privilege, as Prof. Lowell's guest, of observing Mars through nearly one presentation,† in the great 24-inch refractor.

Few people have had the opportunity of observing Mars at Flagstaff, and there is much skepticism afloat concerning the character of the markings of the planet, more especially as regards the double canals. So the writer proposes to give a short account of what can be seen, in the Lowell refractor, in one presentation, by any one of good eyesight, who is somewhat familiar with the use of a telescope. The writer also wishes to give a description of the methods employed in observing, and the reasons for using them. He will also give a few reasons, which appear to him conclusive, to show that the double canals are actual phenomena, and not the result of diffractive effects in the telescope.

Few astronomers appear to realize how exceptionally excellent the seeing is in the clear dry air of Flagstaff, on a quiet night. It is so good, in fact, that a comparative novice appears to be able to see the planet more distinctly in one presentation there than Schiaparelli, at Milan, ever did.

During the time of the writer's observations, the diameter of Mars increased from 12 sec. to 18 sec. The eyepiece used in observing was usually a 25-millimeter orthoscopic, Zeiss, which gives a remarkably large flat field. This gives, on the 24-inch refractor, a power of 393. So that the apparent size of the disk of Mars was about 2.6 times the diameter of the moon, as seen by the naked eye, at the beginning of the writer's observations, and 3.9 times at the end.‡ This is amply large enough to distinguish a vast amount of detail, when the seeing is sufficiently good to disclose it. Sometimes, when the seeing was unusually good, an eyepiece of 20 millimeters would be tried, giving a power of about 490; but this was rarely used to advantage. When the seeing required a less power than the 25 millimeters, the planet could not be observed satisfactorily.

A circular disk was fitted over the eyepiece, containing an assortment of orange-yellow, and neutral-tinted glasses; any one of these could, at will, be revolved in front of the eyepiece. These glasses serve in a marked degree to bring out the contrasts on the planet. How little effect chromatic aberration plays in the observation of planetary detail may be judged from the fact that all the observers at Flagstaff preferred a neutral-tinted glass to a monochromatic one.

The action of a shade in bringing out detail appears to be somewhat as follows: In viewing a point of light through a telescope of a given aperture, the first minimum of the curve of diffraction, or the middle of the first *dark ring*, will always be at a given distance from the point of light, but the spurious disk will fade away, out of sight, before it reaches the minimum; and the fainter the point of light, the smaller the spurious disk. As the point of light approaches invisibility in the telescope, the spurious disk approaches zero. Now, suppose we consider the light bordering a dark line on Mars as made up of numberless points of light. These points of light are excessively faint, compared with points of light on the sun, or with the light from a star. Their spurious disks are therefore extremely small, so that very little light spills over onto the dark markings; and that is the reason we are able to make out such fine detail on the planet. Now, although small, the spurious disks of these numberless points do diffuse some light on the fine dark markings. By using a shade, we decrease the light from these points, and thus reduce the size of their spurious disks. Therefore less light falls on

* Popular Science Monthly.

† From April 28 to June 2, 1907.

‡ With this power Mars appears about 5.2 times the diameter of the moon at opposition in 1907.

the dark markings, and the sharpness of their edges is increased.

It is further found at Flagstaff that diaphragming the aperture increases the seeing. Langley, in his article on soaring birds, has shown that there are constant small changes of velocity "within the wind." Now these pulsations must cause waves of rarefaction and condensation, which may be represented as an irregular wave curve, sweeping past the objective. This will cause the planet to swing in the field of the telescope, as the rays are refracted by a layer of denser or rarer air. Now it is evident that the smaller the aperture of the objective, the less variation of the curve will there be in front of the objective at any given instant, or the more homogeneous the air in the path of the rays entering the eye at any given moment. So that, though a smaller objective will not diminish the swinging of the planet in the field, it will diminish the blurring within the planet, and help bring out the detail. Thus, the smaller the objective, the better the seeing, other things being equal. In practice the best results were obtained with a 12-inch diaphragm, as below this the loss of light and of effects due to increasing the size of the spurious disk began to be more powerful factors than the advantages gained from better seeing.

So importantly essential are the shaded glass and the diminution of the aperture to the study of Martian detail at Flagstaff, that without these aids it would be excessively difficult to make out any of the fine detail on the planet.

It is a mistake to suppose that an observer who has a very keen sight for a small star will necessarily be a good observer of planetary detail. Indeed, it often seems to be the reverse; as if an eye, sensitive to light, were not as acute for form. Now it is well known that no two objects can be separated by the human eye that do not fall on more than one cone in the fovea, or central pit of the retina. So may it not be that an eye, very sensitive to light, has unusually large cones in the fovea, while one acute for form has small ones?

There seems to be a great reluctance to accept the finer markings on Mars as established facts, and their objective reality has been questioned by all kinds of doubts and theories by all sorts of men. It might be well if some people, who explain away the markings on the supposition that they are optical illusions, would take the trouble to follow up their theories, see where they lead to, and work out what the appearance of the markings would b if due to the causes they suggest.

Professor Douglass, of Arizona, has lately suggested* that the canals are nothing but the black rays that can be seen radiating from a black spot, on a light ground, when looked at with a small screen placed in front of the pupil of the eye, so that the light enters only around the edges. According to Prof. Douglass, the black oases are the only real things in the canal system, while the canals themselves have no tangible existence, and are nothing more than these black rays issuing from the dark spots.

In the first place, no eyepieces, constructed on any such principles as Prof. Douglass uses to see these rays, are known at Flagstaff. Furthermore, the oases are more difficult objects to see than the canals. The latter are often visible when the former are not. It would seem that even Prof. Douglass should find it hard to admit that, at such times, the canals are visible radiations from invisible spots.

But let us see what the canals would look like if actually due to this cause. These radiations are due to irregularities in the crystalline lens, and are constant for an adult, but vary with each individual. So that any one, looking at the planet, would see an exactly similar set of radiations issuing from each oasis. The planet would be covered with a quantity of black spots, all with similar radiations, and all absolutely independent of each other. For no two radiations from different spots would ever, except by the rarest chance, run into each other to form a straight unbroken line, connecting the two spots. The radiations would also be entirely different for each individual. As one of the most striking features of Martian detail is the manner in which the canals connect and interlace the oases, further comment seems unnecessary.

It has also been suggested that the so-called canals may not be lines at all, but merely a disconnected string of broken markings, a sort of irregular dotted line.

A series of observations at Flagstaff, conducted by several individuals, has shown that the eye is extremely sensitive to a break in a line. A series of lines 0.3 millimeter wide, was viewed from a distance of 17 feet. Each line was made up of 10-millimeter sections, separated by small intervals that were the same between the sections of each line, but differed for every line. It was found that a line, whose sections were 0.5 millimeter apart, was visible as a continuous line. A line with the sections 0.25 millimeter apart appeared continuous.

With the power usually used at Flagstaff, the first figures would correspond on a planet at opposition to a line five and a half miles wide* visible as a discontinuous line, if the sections were eight miles apart. That the Martian markings should be composed of a series of dotted lines, separated by intervals never greater than eight miles, would seem far more wonderful than the canals themselves.

There is a widespread feeling that the double canals are due to diffractive effects in the telescope. The writer wishes to state, at some length, why it appears to him that this cannot be the case.

The writer has made many experiments, with various telescopes, on dark lines on a light field viewed by reflected light. In no case has he been able to detect diffractive effects that in any way resemble the double canals of Mars, as seen in the Lowell refractor, while, on the other hand, parallel lines, close together, bear a striking similarity to the double canals.

In dealing with this subject, it is surprising to find how little is really known of diffractive effects caused by a dark line on a light field. This is the gist of the whole matter, and is a very different thing from the well-known effects of diffraction obtained when viewing a point, or a line, of light on a dark field.

In viewing a luminous point on a dark field through a given telescope the distance of the rings of diffraction from the center of the spurious disk may be easily found from the formula $\phi = \frac{c\lambda}{r}$, where ϕ is the angle measured from the objective to the focus; c is a constant for each maximum or minimum; λ is a wave length, and r is the radius of the objective. Now, the second maximum, or the radius of the first bright ring, measures about 0.31 sec. in the Lowell refractor. If we extend this point to form a line, the ring will be transformed into two lines, one on each side of the source of light, at a distance of 0.31 sec. from it, and, since the second maximum has but 0.017 the intensity of the first, the outlying lines will be but 0.017 of the brilliancy of the central one.

On Mars we have to consider dark lines on a light field, and little seems to be known of their diffractive effects. There is a disposition to assume that we are here dealing with an inverted diffraction curve. Personally, it seems to the writer that there is no similarity between a bright line, whose light waves produce diffractive effects, and a dark line that emits no light waves. But let us assume that, somehow, the dark line on a light field will produce the same diffractive effects as a light line on a dark field. Then, were the double canals due to this diffraction, they would appear as follows on the planet, when seen in the Lowell refractor. Each and every canal would appear triple, the outer lines would always be separated by 0.31 sec. from their primary, and be 0.017 less distinguishable than it. Furthermore, there would be a dark ring around every oasis. No triple canal has ever been observed on Mars, nor has any ring ever been seen around an oasis.

The distance from the first minimum to the second maximum on the diffraction curve measures about 0.08 sec. in the Lowell refractor. Now, if the double canals were dark bands of a width of 0.16 sec., then the points of light on the planet, at such a distance from the band that their first minima fell on its edge, would cast the light of their second maxima in the center of these bands, and these maxima, from the points on each side of any band, would overlap.

It is conceivable that such an effect might look something like a double canal, were it not for the fact that the diffracted light from all the other neighboring points of light would swamp and drown any such illusion. Supposing, however, that the double canals were really such dark bands, illuminated in their centers by the second maxima of the fringing light, then the double canals would always appear very nearly 0.16 sec. apart, which would correspond to about 1.5 deg. on the planet, when its diameter was 12 sec. But as the planet approached, since the distances apart of the maxima and minima in the focus of the telescope remain constant, the widths of the bands would no longer fit them, and the effect would be lost. Thus it follows that these bands of uniform width could never appear double, except at one given distance of the planet.

There are certain rules that the double canals should observe if they were due to diffraction, but they follow none of these. They should (since the size of the rings of diffraction remain constant through a given aperture) appear nearer together, in degrees on the planet, as Mars approaches; instead of which they remain the same size. They should (as diffractive effects vary in size inversely as the radius of the objective), as the objective is diaphragmed down, appear farther apart; but in fact diaphragming has no effect on their width. Not only should all the canals appear double, but they should all seem the same width. Less than one-eighth of the canals have ever been seen to be double; and the double canals vary from each other in width, ranging from 2 deg. to 5 deg.

If the double canals are really due to diffractive effects, how is it that only those are able to distinguish them whose eyesight is sufficiently good to obtain an exceptional view of the planet? Should not any one who can see the single canals be able to see them double? However, these remarks are probably quite useless. No one of good eyesight, who has seen Mars at Flagstaff, on a night when the seeing is really good, needs any argument to convince him that what he sees is real. And no one who has made up his mind beforehand, without seeing them, that the double canals are due to diffraction, is likely to be influenced by these words.

It would seem almost unnecessary to state that no one for a moment supposes that the lines that one sees are actual streams of water. They are thought to be broad stretches of vegetation, dependent on channels of water running through them. So would the valley of the Nile appear to a distant observer, who would distinguish the dark fertile valley against the sands of the desert, long before he could see the river itself.

During the writer's visit to Flagstaff, he saw 77 canals, 20 oases, and 11 double canals,* all of which, with one exception, could be readily identified on some one of Lowell's maps, though it was sometimes necessary to consult a map of an earlier date than the opposition of 1905, to find them. Each of the drawings is the accumulated result of some 15 or 20 minutes at the telescope, so that no one of them represents everything seen in a single night.

It must not be imagined that any drawing represents what the observer sees the moment he looks through the telescope. Instants of exceptional seeing flash out, here and there, at different spots on the planet. It is not till the same phenomena repeat themselves in the same way, in the same place, a great number of times, that the observer learns to trust these impressions. One has to keep one's mind constantly at the highest pitch to catch and retain what the eye sees.

It is like looking at a Swiss landscape from a high Alp, with the summer clouds sweeping about one. Now the mist rolls away, revealing a bit of the valley, and shuts in again in a moment; while in some other spot the clouds break away, and disclose a jagged summit, or a portion of a shining glacier.

Any one who has been fortunate enough to have had a really good view of the lineal markings on Mars is bound to be much impressed by their artificial appearance. So that, unless he has an inborn prejudice against the idea, any theory that accounts for the canals as the effort of intelligent beings to accomplish some definite object will not appear fanciful.

Lowell's theory that we have here evidence that the inhabitants of Mars are struggling to preserve their existence by a planet-wide system of irrigation seems to be gaining ground.

It would seem, in all fairness, that a theory that fits all the observed facts as beautifully as Lowell's does deserves something better than disdainful disrespect, even from the most conservative. It is certainly far better than any theories and objections that do not meet the facts at all. As yet no other theory has been suggested that in any way accounts for the Martian markings. Until one is evolved that accounts for the facts better, Lowell's theory should be accepted, by the most skeptical, as the only working hypothesis yet devised.

A very noteworthy achievement in the recent study of Mars is the series of remarkable photographs of the planet, taken by Mr. Lampland at Flagstaff. Already he has succeeded in photographing many of the canals, and at the date of this writing he has just photographed the Gihon double.

It seems as if, with the methods at present available, we probably shall not greatly increase our present knowledge of the planet. Even photography will probably be useful chiefly as a means of convincing the skeptical. But who can tell what the future may have in store? What astronomer of the early nineteenth

* SCIENTIFIC AMERICAN SUPPLEMENT, No. 1643.

* Various observers have experimented at Flagstaff at different times with wires stretched against the sky, viewed at ever increasing distances. The distances at which a wire was distinctly visible varied with different individuals, and corresponded to an angular width for the wire varying from 0.69" to 0.98". Looking at Mars at opposition, with a power of 400, these angles would correspond on Mars to widths of from 0.31 to 0.43 mile. Making all possible allowance for loss of light, etc., in the telescope, it seems probable that, under favorable circumstances, a line less than a mile wide could be detected on the planet. By comparison with the finest micrometer threads, some of the single canals are estimated to be as much as 35 miles wide. The width of the various double canals, which remains constant for each canal, is estimated to range from 2° to 5° on the planet. This is found, by various terrestrial experiments at Flagstaff, to be far wider than lines that can be easily separated by the eye.

* There are known at present 436 canals, of which 51 are double, and 186 oases. These are never all seen at one opposition, not only because of the different tilts of the planet, but also because neighboring canals alternate in appearing and disappearing at different oppositions. Accepting Lowell's theory that the canals are areas of vegetation bordering artificial channels for irrigation, this could be accounted for by the fact that when the canals do not appear, the land is lying fallow.

century would have dreamed of the possibility of detecting the composition of the stars, or determining their velocity in the line of sight? Some day a new method may increase our knowledge of Mars, as much as the discovery of the spectroscope opened up the heavens.

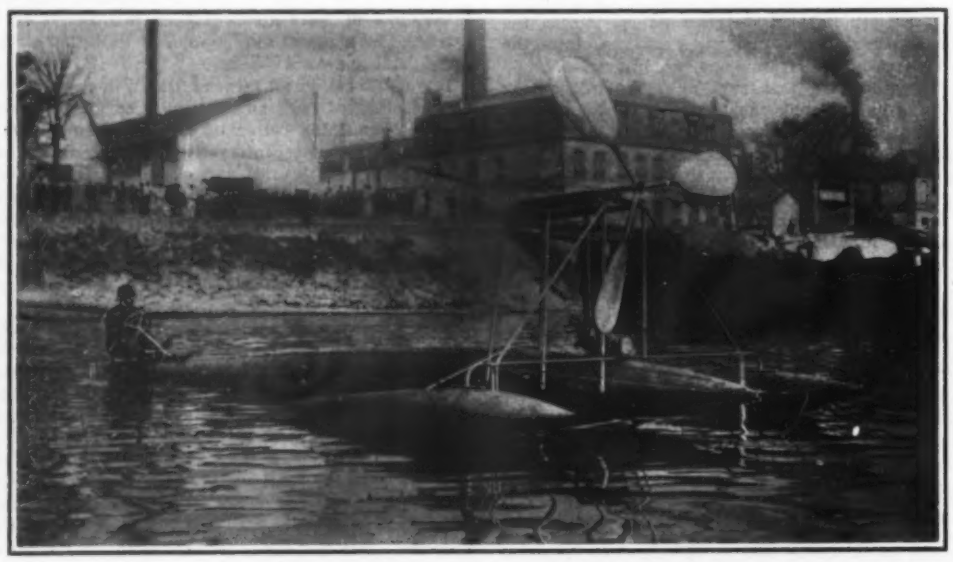
To most people "the proper study of mankind is man." But to those of us to whom the fact that we believe we have detected evidence of intelligent life in another planet seems of absorbing interest, Mars appears by far the most fascinating object in the heavens.

SANTOS DUMONT'S NEW HYDROPLANE.

A CRAFT BUILT TO MAKE SIXTY MILES AN HOUR.

In an effort to win a ten thousand dollar bet made with M. Charron, to the effect that he could build a hydroplane which would travel 100 kilometers (62 miles) an hour, Santos Dumont has recently constructed the novel craft which we illustrate. This new hydroplane consists of one long cigar-shaped pontoon 10 meters (32.8 feet) in length, and which is placed between two similar smaller floats 1 meter (3.28 feet) long. The three floats are fastened together, and a long, narrow plane, 13.12 feet long, extends crosswise from one of the small outer floats to the other. Another plane 4.92 feet long is placed transversely at the rear. The construction of the apparatus is apparent from the photographs. The floats are built up upon a framework of wood and aluminium covered with a rubber-treated fabric which is air and water tight. They are inflated with compressed air, in order to increase their stability. A 16-cylinder, 120-horse-power, V-type motor is mounted on the framework which carries the air propeller. The motor drives the latter direct. The helmsman sits in a small seat at the rear end of the center float, and steers the hydroplane by means of a wheel. In one of our photographs the new craft is shown being towed at a good speed by a fast motor boat. When this test was made, the hydroplane rose until the floats were completely lifted out of the water, and it glided upon its two planes with apparently good stability. The total weight of the new craft is not much more than 500 pounds. On October 17, Santos Dumont took out his hydroplane for the run which was to win him the $10,000 bet of M. Henri Deutsch. The wash of a launch capsized the aeronaut, with the result that he put off the test for another day.

TESTING SANTOS DUMONT'S HYDROPLANE.



THREE-QUARTER VIEW OF THE HYDROPLANE.

THE BATTERY TUNNEL, NEW YORK.

So much has been said, both in the New York newspapers and by residents of Brooklyn, about the delay in completing the battery tunnel which is to link the railroad systems of New York and Brooklyn that the recently organized Public Utilities Commission called upon the chief engineer of the tunnel for a report detailing the present condition of the work. The work has been sublet in three sections, and it is the second section, passing under the East River, which has been delayed. According to the engineer's report, however, it is now in a fair way of being put in operation within a period of two months.

This tunnel is a double tunnel, so designed that trains will run in separate tubes in going to and from Brooklyn. Some details are given in the report of the midriver section, which extends from the end of the rock formation in Manhattan to the cross-connection for the sump in the rock reef located on the Brooklyn side of the river, and includes about 500 feet where the foundation of the tube is in fine sand. In these stretches there are seventeen concrete pile bents under the north tube, and fifteen under the south tube, spaced about 30 feet apart, and extending to hard material at depths ranging from 5 to 60 feet. The calking in this section is in good condition. The reinforced-concrete bottom and the drain pipes are in place over the whole extent of the piled stretch in the north tube, and over the westerly half of it in the south tube. About 300 feet of bench have been placed in the north tube, and about 100 feet in the south tube. No roof concrete lining has been placed in this section in either tube.

Generally speaking, the tubes are practically complete and ready for track laying and the installation of the signal system, except for the section from the middle of the river to the Brooklyn shore. In this particular stretch of the tunnel all kinds of work is rapidly being done to finish the tubes. The reconstruction work is entirely finished, the piles are all in, and the lining has been made watertight. The principal work now remaining to be done before laying track consists in lining the roof and sides of the tunnel with reinforced concrete over the two sections where the bottom is in fine sand, and finishing the ventilating shaft in Brooklyn.

So much has been said lately in connection with the tunnel work that I think this an opportune time to make some statements in reference to this part of of the second contract. The influential factor of the company to whom this part of the work was sublet broke down in health and died, and several months ago the company went into bankruptcy. The original contractor, however, advanced the necessary funds, and the work has progressed slowly, due to unfavorable conditions. The contract, as originally drawn, contemplated the construction of a double-tube tunnel about 15½ feet in diameter. The details of the interior finish of this work were not determined at the time of letting the contract, as at that time the exact conditions which would be necessary for the proper operation of the road were not known. Cars had not been designed, nor had the form of contract for them been decided upon.

The section of tunnel as originally designed was made large, so that in case of changes of alinement and variation in the grade the operation of trains would not be seriously affected. On account of the methods pursued by the sub-contractor, the extent of the variation provided for was exceeded, and those portions of the tube in sand have been reconstructed in parts, so that a clearance of 4 inches, as a minimum, can always be maintained throughout the work. In almost all cases this clearance exceeds 4 inches, but the minimum was made to conform to the clearance which exists all along the rapid transit subway in Manhattan, of which this work has been made a part.

For some distance under the tube the contractor deemed it wise to construct piles, as hereinbefore described. These piles, in my judgment, and in the judgment of most of those who have looked into the matter, are unnecessary, but have been constructed by the contractor merely for the sake of an additional safeguard. If the tube is made watertight there is no danger of its getting out of grade. The tube has been constructed of many thousand different sections which have been calked under air pressure, and which, before the work is completed, are made absolutely tight. The calking of these joints has been made under varying pressures, and after the construction of the tube the pressures are greatly reduced, bringing out any defects which may be found in calking. When these defects are found they are immediately made good. At the present time the entire length of the tunnel is without any air pressure, except for a short distance in the south tube, near the Brooklyn shore, where there is comparatively little pressure, and this is to be taken off within a very short time. When this is done, all parts of the work can be rapidly finished, as it will then be possible to put men into this work without air pressure, which, to many, is very objectionable.

The work has been well executed, but like all tunnel work where the conditions are questionable, the time for completion has been extended beyond the contract time. It seems probable, however, that the first cars will be running in November.

THE TRAINING OF RAILROAD APPRENTICES.

G. S. Edmons, master mechanic at Oneonta, N. Y., to the Delaware & Hudson Railroad Company, has issued a fraternal letter to all the apprentices in regard to the class work in drawing, mathematics, etc., for the coming winter. He is looking forward to some general talks with the lads on subjects bearing directly on their daily work; and he will commence by talking the matter over with them. He advances the practical suggestion that apprentices should read the technical papers—including the Scientific American—and suggests a club and interchange of papers.

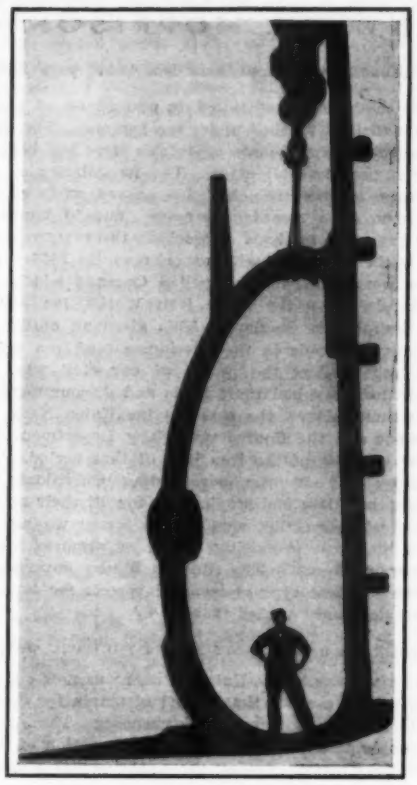
A NEW TYPE OF COLLIER.

FOR THE COASTING TRADE.

THE steel steam collier "Malden" was recently launched at the yards of the Fore River Shipbuilding Company; and while the ceremony was informal, the event was none the less important to the maritime world, as it marked the addition to the United States merchant marine of one of three vessels destined, it is believed, to revolutionize the tidewater coal-carrying trade of the Atlantic seaboard. The "Malden" is the second of the fleet of three vessels built at Fore River for the New England Coal and Coke Company, of Boston, which has a large coke and gas plant at Everett, Mass. The "Everett," which was the first of the fleet to be launched, is nearly ready for her trial trip. The third ship, the "Melrose," will be ready for launching in a few weeks. The ships are made from special designs for the coastwise coal trade, and are also adapted for carrying coal, ore, lumber, or general merchandise in the overseas trade to any part of the world. They are particularly suited for deadweight cargoes, which can be loaded by means of chutes and discharged by mechanical grabs. There are ten exceptionally large hatchways, each 28 feet wide and 14 feet long, with two hatches to each of the five cargo holds, which latter are each 48 feet long. Each of these ships will be 400 feet long, with an extreme breadth of 53 feet, a depth of 32 feet, and a gross tonnage of 5,107 tons.

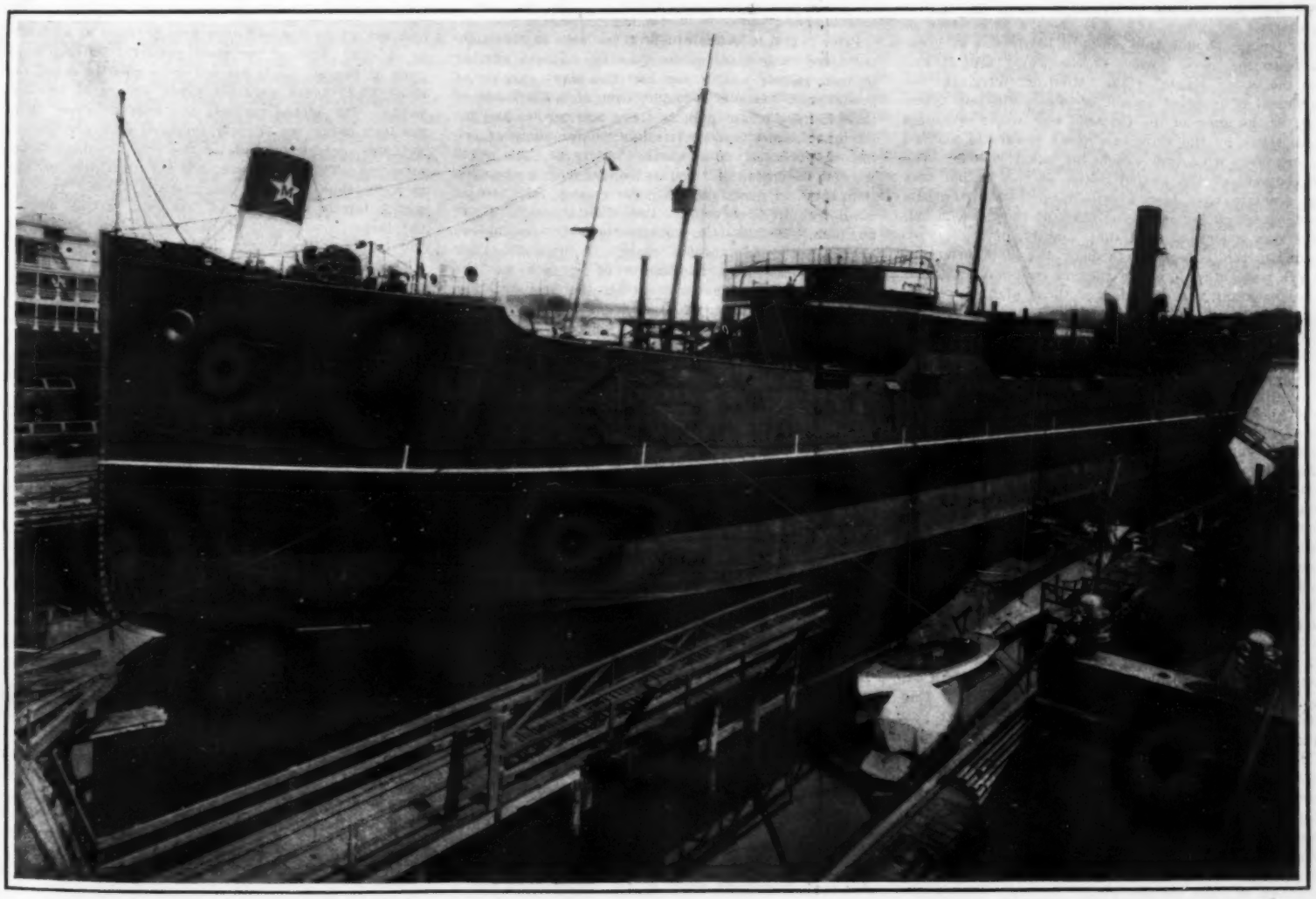
The special feature in their construction is known as the self-trimming system. This consists in sloping the hatchways from their side coamings to the side of the ship, having an angle of about 45 degrees, this triangular prism being utilized as topside ballast tanks, to be filled with water when the vessel is running light. Water ballast may also be carried in the deep inner bottom tanks in addition to the usual fore and aft peak tanks, thus insuring sufficient immersion when running light, providing great stability and guarding against over-exertion or racing of the propeller.

The ships are of the single-deck type, with single screw and triple-expansion surface-condensing engine and four single-ended Scotch boilers constructed for a working pressure of 180 pounds. All the machinery is located aft. The ships will be manned by crews of 35 men each all told. Each ship has eight steam winches, exceptionally powerful pumps enabling the vessel to discharge all water ballast tanks in six hours.



STERN FRAME.

Weight, 13½ tons. The D-shaped propeller aperture in which the man is standing is 21¼ feet high by 7 feet 5 inches wide.



STEEL STEAM COLLIER "EVERETT," SISTER SHIP TO THE "MALDEN."

A correspondent of the Times Engineering Supplement describes the results of the trials of the Field-Morris system for increasing the thermo-dynamic efficiency of the steam engine. He states that by this system a saving of 24 per cent in fuel has been effected. The system consists of adding to the steam a certain proportion of air under pressure, this mixture then being superheated before being allowed to pass into the steam cylinders. The theory, upon which the saving claimed for this invention is based, is not manifest, but it is stated on good authority that the saving in several tests has been considerable, after due allowance has been made for power expended in compressing the air.

HOW RAINFALL IS ABSORBED.

A RECENT number of the Water Supply and Irrigation Papers includes a discussion of the relation between soil character and erosion. If all the rainfall is absorbed, as it may be, by coarse sandy soil, there is no run-off and no erosion. The coarser the soil the quicker the rain, as it falls, is absorbed. Fine soil, on the other hand, will not let the rain permeate it unless the soil has been broken up, as by tillage.

There is room for large storage of storm water in farming soils, and rational farming methods must increase the storage capacity. This is one reason for manuring land, since the presence of humus in the ground makes it more sponge-like. Humus is a substance formed by partial decomposition of vegetable or animal matter which is more or less covered and thus kept from the air. Outside of the improvement of farm soils by cultivation, the only way additional storage can be secured is in forest soils, through the agency of humus.

The functions of humus are (1) to maintain the volume and depth of the soil; (2) to secure the porosity of the soil; (3) to promote the absorption of rainfall by the soil, in retarding the run-off of heavy showers, until the water can be absorbed as the air is gradually expelled from the soil; (4) to act as a mulch and lessen the evaporation of soil moisture.

Where the forest soil is of coarse sand and the ground is level, humus forms least rapidly, because air circulates most freely in the soil and beneath the litter of leaves and twigs from which humus is made. The larger the proportion of clay in the soil, the shallower its depth, and the steeper the slope, the more important is the function of humus in retaining moisture. Its functions in this regard attain a maximum on heavy shallow clays and on steep mountain slopes.

THE DEVELOPMENT OF ARMORED WAR VESSELS.—IX.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

Continued from Supplement No. 1659, page 246.

THE CRIMEAN WAR AND EARLY FOREIGN ARMOR.

It was left for the Crimean war of 1854 to settle the question that naval artillerists and naval designers had so long been speculating upon, of the value of an ironclad vessel, and explosive shells. The French government commenced the construction of five floating batteries in September, 1854, that were launched early in the following year. They were each 172 feet by 44 feet by 9 feet draft. They had a casemate covering the whole deck space, that had considerable "tumble home." The walls of the casemate were covered with 4½ inches thick iron plates, each 3 feet long and 20 inches wide, laid on 27¾ inches wood backing, and secured in place by 1¼ inch screw bolts. They were unwieldy hulks, slightly sharpened at the ends, and driven by a screw propeller, under the most favorable conditions, at not over four knots an hour. They were each armed with twenty-four 50-pounder guns. There were only three of these vessels sent to the Crimea, the "La Devastation," "La Lave," and "La Tonnante." These vessels were an experiment, built in haste for an emergency, without any pretense to finish, with the one main purpose of protection to the wooden hull. These three vessels were located about 700 yards from Fort Kinburn on October 17, 1855, in the assault on that fort, and received most of the fire from the land fortification for four hours, the "La Devastation" being struck sixty-seven times without any other effect on the iron armor than to dent the plates at most to 1½ inches. The British navy had three of the same type of vessels added to their fleet, but they did not arrive in time to take part in the engagement. This was the first battle of ironclad vessels against land fortifications, and cleared the atmosphere of many theories and speculations that had been the topic of discussion of naval experts and naval artillerists for years, and gave them a solid basis to work from. Though this Kinburn battle was of great value to the naval powers of the world, still it was not the object lesson of the "Monitor"-"Virginia" engagement of ironclad vessels of totally different types.

After the close of the Crimean war active measures were taken by the European naval powers in making experiments with iron armor for naval vessels. The government of the United States at this period does not seem to have been greatly interested in the subject, except so far as the building of the Stevens battery was concerned, and that, mainly, of the investment in the enterprise through the appropriations. There were other projects then in contemplation that were engaging the attention of those high in authority, and that were the means of bringing ironclad vessels in a few years to a severe test.

It may be of interest to know what was being done in the manufacture of armor plating in Europe at this period, in a general way. The first armor plate made after the Crimean war, other than for experiments, was that manufactured by Peter Gaudet & Co., at Lyons, France, in 1859, for the French steam frigate "La Gloire Napoleon." These plates were about 6 feet long, 27½ inches wide, and 4¾ inches thick. This firm were the largest iron manufacturers on the continent of Europe at the time, and a few years later were in active competition with the British iron manufacturers, making sample plates of iron armor for trial in English experiments, that gave the British iron manufacturers much concern for their home market for a time. The British iron-hull steam frigate "Warrior" was commenced the same year as the "La Gloire," and the 4½-inch forged plates of this vessel were made in 1860 by the Thames Shipbuilding Company, who were the manufacturers of the best English forged plates for several years. The next year the making of rolled armor plate was commenced in Great Britain for some of the British naval vessels then under construction, but there were many of these plates that were rejected under the inspection, for serious imperfections in their manufacture. In another year there had been such improvement made in the manufacture of the rolled plate, that the merit it had lost had been regained, as the practice in the making of the sample plates for experiments had shown where lay the weak point in its manufacture. John Brown & Co., of the Atlas Iron Works, Sheffield, was the largest and most prominent of the rolled plate manufacturers of that period. Cammell & Co., of Sheffield, first made rolled iron plate for armor in November, 1863. By this time the size of the plates had increased in width to about 4 feet, and in length to 15 feet. The Atlas Iron Works made in 1863 some plates that were first rolled in the shape of armor plate, and then finished under the hammer. The making of rolled armor plate up to this time had been in its first experimental stage. The irregularity of the toughness of the iron, and its uneven surface, had now been in a measure overcome, due to improved machinery and methods of working the raw material, that could only come with experience. In 1866 6-inch plates were rolled by Cammell & Co., and 8-inch and 9-inch plates by the Atlas Iron Works, for vessels then building in England. This gives an outline of the progress made in the development of iron armor in Europe during the period of our civil war. It shows that they had their trials and discouragements in its manufacture, the same as the Union Navy Department and the Confederate Navy Department had in the building of the ironclads of that period. The difference lay in the surrounding conditions; in Europe they then had ample time for all their experiments, while on this side of the water we had to select the most promising design of armored vessel that was offered. The United States government wanted the best type of ironclad vessels for immediate service, and "wanted them bad."

IRONCLADS OF THE NAVY DURING THE CIVIL WAR.

The civil war in the United States was now on, and there was in a short time a sort of mania for designing ironclad vessels for naval purposes. The American people paid a high price for the education of their naval constructors during the experimental stage of ironclad vessels in this country, but probably not so large as Great Britain or France. The "Monitor"-"Virginia" engagement brought the revolving turret into favorable consideration, and during the civil war the monitors were the prevailing type of our ironclad vessels. The turret is in use even to-day.

Prior to 1861 it is doubtful if there were in this country more than three or four, as the highest number of iron rolling mills, that had the plant capable of producing a plate of wrought iron of a thickness of three-fourths of an inch, as there was no demand for its manufacture, except it might be for some experimental purposes. Our marine boilers at that period were so designed, and operated under such a pressure, that they required, generally, no greater thickness of plate iron in their construction than three-eighths of an inch. Besides, the construction of wrought-iron bridges was yet in the first stage. In the hulls of our iron merchant fleet, five-eighths of an inch was the thickest plate iron that was used in their construction. It was in the building of the Stevens battery that iron of a greater thickness was used. The only iron-rolling mills on the Atlantic coast that appear to have been equipped at this period to roll plates of one inch in thickness were the Canton Rolling Mills of H. Abbott & Son at Baltimore, Md., where the plate iron for the "Monitor," and most of the subsequent vessels of that type, was rolled. The Phœnix Iron Company, of Phœnixville, Pa., made for the Stevens battery, prior to 1862, some heavy plates, 6 inches to 8 inches in width and 2½ inches to 3 inches thick, and cut in short lengths. They also made in 1865 thirty iron logs, 24 feet long and 8 inches square, that were used on some of the western river monitors, and in some of the "Kalamazoo" class of monitors on the coast, as a backing with the wood, for the armor plate.

The heavy forged or hammered armor plates of that period were made by the Nashua Iron Company, of Nashua, N. H.; the Alger Forge Company, of South Boston, Mass.; the Franklin Forge, of Tuguot, Daily & Co., of New York city; the Bristol Forge Company, of Bristol, Pa.; Brown & Co., the Wayne Iron Works, Pittsburg, Pa.; the Paterson Iron Company, of Paterson, N. J., and the Reading Iron Company, of Reading, Pa. It is altogether probable that the Wayne Iron Works, the Franklin Forge, and the Bristol Forge furnished the larger part of this forged iron plate. The Wayne Iron Company was kept almost steadily employed day and night from 1862 to 1865 with a heavy steam hammer forging these iron armor plates for the government work, of 4½ inches thick and 12 feet long, that were subsequently planed on all edges and dovetailed at the mill, ready to be placed on board the vessels, after the bolt holes were drilled. "With the clumsy tools then in use at the mills the production of this armor plate was necessarily very limited, amounting to not more than one finished plate in each turn, or two plates daily."

The Franklin Forge had the largest forging plant in the United States prior to 1860, for we find in 1856 they had in operation five steam hammers: One Condie of 7½ tons; one Nasmyth of 2½ tons, one of 1½ tons, and one of 10 hundredweight; and one Kirk of 10 hundredweight. This Condie hammer was claimed to be the largest steam hammer in use in the world at the time.

The Western States at this period had several iron-rolling mills having a large output that were of much service to the national government at the outbreak of the civil war. Among them were those situated on the Ohio River, there being ten in Ohio, six in Kentucky, and one in Indiana. There were also three of some size in St. Louis, Mo. It was at the mills of Gaylord, Son & Co., at Portsmouth, Ohio; Alex Swift & Co.'s mill at Newport, Ky.; and the Soho Iron Works of Moorhead & McClean at Pittsburg, Pa., where the armor plates were made that were used on the gunboats built by James B. Eads & Co. for the western rivers. That some of these mills were fitted for producing heavy plate iron at this early date of our domestic troubles, without a rebuilding of their rolling-mill plant, is shown by the fact of plates being used by an army officer for experimental purposes, as to its resisting power, in six weeks after the signing of the contract for the construction of the vessels on August 7, 1861. It would thus appear that this heavy plate, or armor plate so called, was made prior to the contract for the construction of the original "Monitor," which was on October 4, 1861.

These experimental plates of iron for Eads gunboats were subjected to the tests on September 19, 1861. They were made across the Mississippi River from St. Louis under the supervision of Lieut. A. R. Buffington, U. S. A., who was assistant ordnance officer at St. Louis arsenal. The iron plates for the experiments were bolted firmly to oak blocks about 16 inches thick, and the whole fastened in a firm position at an angle of 45 deg. Two of the most powerful Parrott rifled guns at the St. Louis arsenal were used in firing the shot. The ranges were 800 yards, 500 yards, and 300 yards. The plates resisted the shot at every turn, the iron being but slightly indented at every impact, but not a crack or sign of the iron breaking being apparent. The target was then set up nearly vertical at a distance of about one hundred yards. The ball struck fair in the center of the plate, rapidly moving the target around out of its position, and shattering the ball into fragments, but leaving the iron plate without material damage. This concluded the trials, and the iron plate was pronounced as fulfilling all the requirements for the purpose intended.

It may be interesting to know something of the production of this early heavy plate iron for armor by the Gaylord Rolling Mill Company. They were the first to make this iron; then it was rolled at Swift & Co.'s rolling mill, and also by Moorhead & McClean. These plates from the Gaylord mill were rolled in grooved rolls. They were made from piles composed of charcoal iron from Tennessee, and were built up of a rerolled top and bottom plate about 1¾ inches thick, filled in between with charcoal bar ⅞ inch thick, with one row of muck iron bar to improve the welding qualities. It was necessary when the Gaylord rolling mill started on this class of work to rebuild their heating furnaces, three in number. These were of the old-style draft furnace, using coal as fuel, and were built by the Johnson Furnace Company of Pittsburg, Pa. They had to purchase rolls, drill presses, bending and shaping machines, etc., as the manufacturers of the iron finished the material ready for fitting in place on the vessels. After the war the company bought many of these heavy iron plates, and reworked them into boiler plate iron.

In 1862 and 1863 there were several plate-iron mills at Pittsburg, Pa., that increased their facilities so as to roll plate iron of one inch to two inches in thickness and ten feet long. They were the Sligo Works of Lyon & Shorb, Birmingham Works of McKnight & Co., Reese, Graff & Dull, and the Wayne Iron Company.

Moorhead & McClean in 1861-2 rolled iron plates 120 inches by 36 inches by 1½ inches for the government. In 1864 they rolled plates 192 inches by 39 inches by 3 inches, and in 1865 and 1866 plates were produced 4 inches, 6 inches, 8 inches, and 12 inches thick, 54 inches wide, and 216 inches long. Some of these were target plates, and some made for turret plates. The turret plates were curved by a set of curving rolls, much after the style of a blacksmith's tire rolls, after

the plates had been rolled flat. For almost three years this mill rolled iron plates on orders for government work, of plates 16 feet by 39 inches by 3 inches.

Mr. George F. McClean, of Moorhead & McClean, went to Europe about 1862, and had made for his firm a duplicate of a portion of John Brown & Co.'s rolling mill at Sheffield, England, who were at the time the largest manufacturers of rolled-iron armor plate in Great Britain. After being newly equipped, which was about the time the western river monitors were commenced, the mill was operated very successfully in producing armor plate at Soho Mills, this name being given to the plant at that time, and which name it still retains, although now owned and operated by the Jones & Laughlin Steel Company.

There were, during this experimental stage of the development of iron armor, as many opinions held in this country regarding the subject as there were entertained in England and France, though the "laminated" system had a hold but in this country. A view of the subject is given by an authority in the United States in 1862. "The Navy Department expresses a decided preference for thick plates of iron armor for ships, in preference to several layers of thin plates of the same aggregate thickness. The European practice would seem to confirm this view of the case. But the facts and principles involved are all to the contrary. The elaborate experiments of Mr. Stevens show that while the pile of thin plates may be more indented, the solid plate of equal thickness is more shattered and weakened by a ball of given force. The thin plates bend individually, and the inner plates are hardly weakened at all; but the whole of the thick plate must either give way altogether, or be weakened in every part. Its fracture is irregular, and generally greatest on the back of the plate, and the effect taken as a whole is more destructive. The same facts were fully illustrated in the engagement of the 'Monitor' and 'Merrimac.' While the turret of the 'Monitor,' composed of eight layers, each an inch thick, was only indented 2½ inches by a shot striking square and flat upon it, one of the solid plates, 9 inches thick and 12 inches deep, forming a part of her pilot house, was completely broken in two by a similar shot, and opened five-eighths of an inch on the back of the plate. Thus eight inches of thin plates stood better than 9 inches solid iron. This was due in some degree to the connection of the thin plates with the surrounding mass, while the solid plate had only its individual strength. When the armor of ships is composed merely of blocks pinned to the frame, and having no lateral connection, it adds no strength to the structure, but on the contrary it adds its immense weight, which is constantly tending to strain and fracture the other parts of the vessel, especially at sea. The loosening of the solid plates of the 'Warrior' and 'La Gloire,' and the straining and leaking of the vessels due to it, have already been sources of immense trouble and expense. But when the armor is composed of layers of thin plates breaking joints, the whole structure is in effect one continuous plate, forming a girder of immense strength. The armor thus serves the double purpose of giving the vessel extraordinary strength and of better resisting the enemy's projectiles. But there is one more consideration in favor of thin plates. Their cost is very much less than that of thick plates. The former are the product of our iron-rolling mills. The latter cannot be made by more than one or two rolling mills in this country, if at all. Two-inch plates cost 50 per cent more than boiler iron, and the cost of 3-inch and 4-inch plates increases in a very much larger proportion. The 6¾-inch armor of the Stevens battery, composed of thin layers, would cost considerably less than the 4½-inch solid plates of the 'Warrior,' besides being, according to the actual trials, a vastly better protection against shot, and the very backbone of the vessel, instead of a mere dead weight. It is to be hoped these facts will lead to the abandonment of the project of sending to England for thick plates."

It has been generally accepted that rolled-iron or steel armor plate of any thickness over three inches has been a product of our iron-rolling mills of a comparatively recent date; it may be said, since the commencement of the building of our new navy in 1883. While this is correct so far as armor plate for war vessels is concerned, extra heavy rolled-iron plate was the subject of a series of experiments by the Engineers' Bureau of the War Department at a very early period. While this record may be foreign to the construction of armored naval vessels, still the manufacture of such heavy rolled plate, and of such a length and breadth of plate, may be of interest, however, to some of our iron and steel manufacturers of the present day. Just after the close of the civil war, the question of the use of iron armor plate for the protection of our seacoast forts was discussed in army circles. Col. J. G. Barnard, U. S. A., said of these experiments in 1868: "The open embrasure of earth and the gun casemate with an iron front or shield were experimental in the proper sense of the term. They were both designed three years ago, before a single experiment had been made in England for harbor forts, for the first experiments in England on land casemate fronts were made in November, 1865, with a granite casemate, and with a shield on Chalmers's plan, somewhat modified by the English engineers." Combining iron and masonry in fortifications had always been met with objections prior to these experiments, and the result of these tests appear to have confirmed the previous opinion.

The record shows that the tests of these plates were made in November and December, 1868, at Fort Monroe and Fort Delaware. There was an iron barbette embrasure target made up of various sizes of plates, each 12 inches thick, at Fort Monroe. At the same fort there was also an iron shield casemate. The shield was composed of a 12-inch plate, 4 feet broad, on each side of the embrasure, each plate being supported on the back by two vertical iron posts 12 inches by 15 inches, which were bolted to the plates by 2½-inch diameter countersunk-head bolts with nuts and washers, and mortised a foot above and below into the granite masonry. Below the embrasure opening, and lapping 8 inches on either jamb plate, was a 15-inch center or sill piece, 4 feet 8 inches broad and 6 feet 1½ inches high, made of two 7½-inch plates which were bolted at the lappings to the jamb pieces; and above the embrasure opening was a narrow iron lintel, also made of two 7½-inch plates, and lapping on and bolted to the jamb plates, like the sill piece. The whole shield presented a front of 11 feet broad and 12 feet high. This target was completed February 28, 1868, and subjected to the test by artillery on November 20 to 23, 1868.

There was at Fort Delaware an iron casemate shield. This shield was formed of a single front plate 8 inches thick, 10 feet 4 inches broad, and 6 feet high. Behind that, and bolted to it, was a plate in two pieces, the joint between passing horizontally through the middle of the embrasure, 7 inches thick, 9 feet 6 inches high, and 15 feet broad on the whole width of the casemate. Out of the center of this shield of 15 inches thickness was cut an embrasure opening for a 13-inch smoothbore gun. The bracings of this shield consisted of two vertical 2-inch plates of 9 feet 6 inches high and 6 feet wide at either of its extremities, and at right angles to it; and two oblique 2-inch plates of the same height extending from the back of the shield at points nearly opposite to the sides of the masonry opening in front, to the rear edges of those first mentioned.

These plates were all made by Moorhead & Co., of Pittsburg, Pa., in 1866 and 1867. They were made upon the same mill that they had rolled the 3-inch plates on, but had to materially strengthen the mill to roll these extra heavy and wide plates. The length and width of these plates appear remarkable in their having been produced but a few years after the close of the civil war. The dimensions are from official data. They are further referred to on another page. This was the last rolled iron armor plate that was made in this country until the armor plate made for the new navy. This rolling mill never made any forged or hammered plates.

The largest *forged* plate of iron made in this country, of which there appears to be any record, was that on exhibition at the Centennial Exposition at Philadelphia, Pa., in 1876. This plate was forged at John Roach & Sons' Morgan Iron Works in New York city, and was 12⅞ inches thick, 3 feet 8 inches wide, and 10 feet long. It was planed on all edges to show good welding. It was returned after the close of the exposition to the former works, and was subsequently made use of with some of the heavy tools at the works.

In Europe, rolled-iron plates of 14 inches in thickness were the heaviest made up to 1876, when 22-inch thick armor plates were rolled by Cammell & Co., of Sheffield, England, for two Italian war vessels then building.

(To be continued.)

BRASS WASTE IN MACHINE SHOP AND FOUNDRY.*

By WALTER J. MAY.

BRASS may be taken as being worth about $14.00 per hundredweight in a crude state, and this really represents the loss made when brass is lost or wasted. Of course there are a number of variations in costs of metals and the different proportions used in making alloys, but roughly, at the present time, good machinery brass for materials alone is worth the price mentioned above. This comes out at 14c. per pound, and every pound of brass wasted costs this amount for metal, for which reason some little attention should be paid to the matter.

In the machine shop we get old brass and gun metal, solid pieces cut off new castings, and turnings and borings, these latter, possibly, being to some extent mixed with iron, but in each case the yellow alloys are easily separable from iron, although magnetic metals or alloys will also come over in the ordinary separator. This is at times desirable (but in some cases rather a nuisance) when such magnetic stuff can be melted with the brass and not cause injury to the castings.

In the workshop the different classes of metal should, as far as possible, have separate bins, the small stuff from the machines being kept separate and usually free from iron, proper trays for catching the metal being used. Still, with all the care that may be taken, some of the more valuable metal will reach the floor and be mixed with iron and dirt, and these pieces, when swept up, should be placed in a box for treatment as they accumulate, for while the dirt does not seriously matter, the iron does, so far as melting is concerned.

Every brass foundry using scrap metal should have a magnetic separator, and wherever iron is mixed with the small stuff it should be separated. The kind of separator used would largely depend on the amount of metal to be treated, but some of the electro-magnetic separators work rapidly and well, the whole of the iron being taken out. A good separator pays well, but still its presence should not reduce the care taken at the machines to prevent mixing iron and brass. Of course iron will float in the crucibles, and nominally it can be skimmed off the surface of the molten brass, but in practice this does not occur with fine stuff, and castings turn up rough and full of specks.

In the foundry itself a certain amount of metal gets into the skimmings, some gets spilled on the floor, and some splashes get into the sand where the flasks are poured, while occasionally some pieces get into the ashes in the furnace pit, although with care this seldom occurs unless a crucible breaks or burns through. The bulk of this metal is recoverable if the pots are always skimmed in one place, as, when sifted, the metal can be picked out of the waste, while metal spilled on the floor or around the molds can be easily picked up. The same may be said of that spilled or dropped into the pit, as by sifting the rubbish and ashes both metal and pieces of coke can be recovered, the coke being useful for other purposes than melting.

Beyond these mechanical wastes there is another which seriously affects the costs of any foundry using any quantity of scrap metal, and this is the melting losses, which are of a very variable character. Practically, these cannot be avoided, and the only thing is to make a very full allowance for them. Rarely will 100 pounds of small scrap produce more than 90 pounds of molten metal. But freshly-made turnings and the like when gradually introduced into a bath of molten metal will not lose much, and this assists in keeping a moderate average for melting. Large scrap does not lose so much as the fine stuff, and probably an average loss of 10 per cent will be all that occurs on the year's melting. With large scrap cut from new castings the loss should be very small, but when old scrap is dealt with the loss becomes larger. Even with new ingot metal there is some loss, but, of course, not so much as with scrap.

The melter has a lot to do with the amount of loss, however, as a careful, skilled man will keep things as low as possible, while effecting other savings as incidentals. A good man saves fuel and reduces his metal without burning the life out of it, and in doing this he reduces the melting losses. Besides this, he keeps a reducing atmosphere in his crucibles, and thus prevents further oxidation, the methods used being of the simplest as a rule. A handful of charcoal in the bottom of the pot, or even a piece of coal, will produce a reducing atmosphere, while a handful of gypsum or plaster of Paris will clean the dirtiest brass you can get. For some metals he will use ordinary coal gas as a deoxidant, and so on.

The use of fluxes in melting metal is not at all necessary, but at the same time, as a matter of expediency, the use of fluxes may be adopted. Naturally, there is considerable difference between necessity and expediency, but when the latter can be made to effect some decent saving in cost, or to reduce some loss or losses incident to working, then the expediency treatment is best. Anyway, if we spend, say, an extra penny per hundredweight on our metal and get perfectly sound castings every time, it cannot be said not to pay, but all the same perfect castings can—and should—be obtained without the use of any addition to the metal, even though only the commonest scrap be used.

Taken as a whole, where the foundry is attached to the machine works, the total loss of metal—not iron or steel—should be kept down to about 3 per cent on the metals purchased for alloying, provided scrap is not purchased, and if this cannot be done there is fair ground for a searching inquiry into both materials and methods, and probably much closer supervision will be found necessary in all departments through which the metals pass. Above all, pay occasional visits to the bins for iron turnings, and see how much yellow metal reaches them.

* Abstracted from the Practical Engineer.

Cleaning Optical Glasses.—Rub with tissue paper slightly moistened with water containing a few drops of alkali. Wipe with chamois skin.

ELEMENTS OF ELECTRICAL ENGINEERING.—III.

THE ARC-LIGHT DYNAMO.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1658, page 230.

A more familiar designation would be "series arc dynamos." It is now hard to realize how meager were artificial illuminants before the advent of electric lighting. Streets were dismally and even dangerously dark; halls, stores and factories served with gas and oil illustrated unhealthful and dangerous conditions. There was, therefore, great incentive to produce the arc light on a practical scale, and the spectacle of Gramme's magnificent lights, in Philadelphia in 1876, first revealed to the public that electricity had other commercial uses than to operate telegraph instruments. Though some timid people seemed to be frightened by the overwise prophecies of physicians as to the dangerous effect of intense brilliancy upon the optic nerves and brain, evidence was not lacking, that with economical apparatus at hand to produce the arcs in sufficient numbers, there would be plenty of customers.

Two men stand out conspicuously as having solved the problem. They were Charles F. Brush, of Cleveland, Ohio, whose principal work was done between 1876 and 1880, and Elihu Thomson, early of Philadelphia, Pa., and then of Lynn, Mass., who made valuable improvements and extensions in the early '80s. Brush's machines were of much better mechanical design than Thomson's, but the latter had the more effective regulator. The personality of the men, the successive steps in the development of their "systems," the competition between the two manufacturing companies that were organized, the loyalty of the employees at the Cleveland and Lynn factories, are matters of historic interest to those who were associated in the work in those stirring times, but their narration need not cause a diversion in this article. It is interesting to note that Prof. Thomson originally sold his patents to the Brush Company, then with the assistance of Prof. Houston, bought them back and organized his own company; after interesting further capital and removing to Lynn, this "Thomson-Houston Electric Company" obtained a controlling interest in the Brush Electric Company, and later, in the days of the General Electric Company—formed by the consolidation of the Thomson-Houston and Edison interests—the pioneer company was wholly absorbed and disappeared from active existence. Brush himself, however, had prospered richly from his inventions and has had the satisfaction of seeing the distinctive construction of Thomson abandoned, and his own, with the addition of the Thomson regulator, substituted for the recent largest sizes of arc dynamos. A personal article by Brush himself regarding his early experiences forms highly interesting reading in the Century Magazine for May, 1905.

Without stopping to follow the successive steps in the early development of the two systems of these inventors, it will be well to explain what necessity exists for constant current working, what are the electrical and magnetic conditions that will allow a dynamo to supply such a current, and then to observe how these conditions were met in the Brush and Thomson apparatus.

If two or more lamps are to be operated from the same dynamo, economy of wiring would dictate that they be connected in series with each other; each lamp would then be sure to receive the same current; the dynamo should then be designed to supply a voltage proportional to the number of lamps, but a current invariable in value. A given circuit would, therefore, be generally associated with some one dynamo, and any one customer could not be served without energizing the entire line; for even a hundred lamps in one circuit, the requisite voltage might be dangerously high, consequently for thousands of lamps ordinarily supplied from a central station many independent dynamos would be needed. With lamps or other devices connected in multiple, or parallel, the potential is limited to that demanded by one unit, each customer is wholly independent of others, and there is no limit yet reached in the size in which the generators may be built. For this reason interior arc lamps are now commonly connected in multiple, the

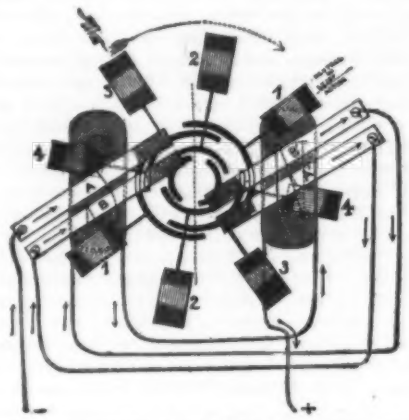


Fig. 11.—Connections of 16-Light Brush Arc Dynamo.

expense of the copper being justified by the use of lamps requiring small currents and by the more general demand for all-day service.

In the early days, however, street lighting was of the first importance, and private customers were considerably scattered, so the series connections of arc lamps were very properly considered to be necessary. Street lighting alone is likely to comprise the sole use of such circuits in the future. With this one idea in mind, of operating lamps in series, demanding extreme variations in voltage, the hardest problem was the first to be presented; even now, the theory of arc dynamos is not very well understood and their operation is still attended with adverse conditions.

The requirement of constant current and variable voltage is just the opposite of the natural capability of a dynamo. A field magnet is ordinarily designed of a certain size to carry a definite flux of force, and would not be considered as giving good returns if operated at much above or below that amount; the number of conductors on an armature is obviously fixed; the speed of rotation, for practical reasons of good engineering, is maintained very uniform. Upon these three quantities—the field flux, the number of armature conductors, and the speed, as explained in a preceding article—depends the value of the electromotive force, and if they are fixed, the electromotive force is necessarily constant; then, dependent upon the resistance of the circuit, current of greater or less strength will flow. This condition of operation is sought and attained in machines now used for general purposes of electric supply; they are classed as "constant potential" generators, and will form the topic of the fifth article. Early dynamos were rather lean in their magnetic circuits, and considerable copper wire was used in order to bring their magnetism to its full value; these proportions are now known to be far from the proper conditions for constant potential working, so unwittingly there was a contribution in the right direction to assist the early seekers after constant current machinery; they quickly found that the less iron and more copper in a dynamo, though more expensive to construct, the more satisfactory would be the behavior. By such proportions, three essential factors were presented—a highly saturated field magnet, strong armature reactions, and much self-induction. The effect of these three will be separately considered.

A numerical example will assist in making apparent the value of a magnetically saturated condition of the iron of the field. Suppose a dynamo is supplying a circuit of 40 lamps in series; the voltage needed would be about 2,000, and the current, presumably, 10 amperes; let half of the lamps be turned off, by short-circuiting them; then only about 1,000 volts would be needed. If no other changes took place in the circuit, the 2,000 volts would still continue to be generated, and therefore result in sending 20 amperes instead of 10 through the lamps; with unsaturated field magnets in series with the same circuit, there would then be nearly twice as much magnetism produced, and this in turn would elevate the potential still higher, so that at the time when a half potential was desired, it would be much more than doubled. The result would be no saving in the driving power, and disaster to the windings of the machine and lamps. If, instead, the normal 10 amperes so highly saturated the field magnet that an increase in the current produced appreciably more magnetism, no actual rise in the voltage could accompany diminished load. Again, if the proper conditions for half load were attained, and full load was thrown on, the dynamo should at once increase its potential from 1,000 volts to 2,000; if there was any delay in reaching this value, the current would momentarily fall to 5 amperes; if this resulted in lessening the magnetism to one-half, the voltage would of course fall, and the current in turn be further reduced, but if the taking away of 5 amperes from the circuit did not proportionately affect the magnetism, no such exaggerated lapse would occur. If a 10 ampere dynamo is desired, it should be so designed that 3 or 4 amperes will about saturate the field, then slight variations in the current above and below normal will be nearly ignored.

The production of magnetism is an invariable result of current flow; even if the inclosed iron is in the form of a ring or drum armature core, the introduction of current at one point of the winding, and its exit at another, will produce definite poles in the circular faces; within the limits of saturation, the larger the number of turns, and a given current, the greater the amount of magnetism. An arc dynamo is a high potential machine, and to generate the requisite number of volts, many turns of wire are needed on the armature, and a high degree of magnetization results. To minimize sparking in a generator it is found necessary to move the brushes forward, in the direction of rotation, and the greater the armature magnetization the more must be this displacement from the mean position. Diagrams could be drawn to show that under these conditions there is a component produced that acts directly against the field flux. It will be at once recognized that such an action is highly helpful in maintaining the current constant, for with the value normally at 10 amperes, a rise to 11 would at once increase the armature demagnetizing component, and reduce the effective field flux, and a fall to 9 amperes would so reduce this reaction as to permit an increase in the flux. Too large a current would therefore tend to reduce the voltage, and too

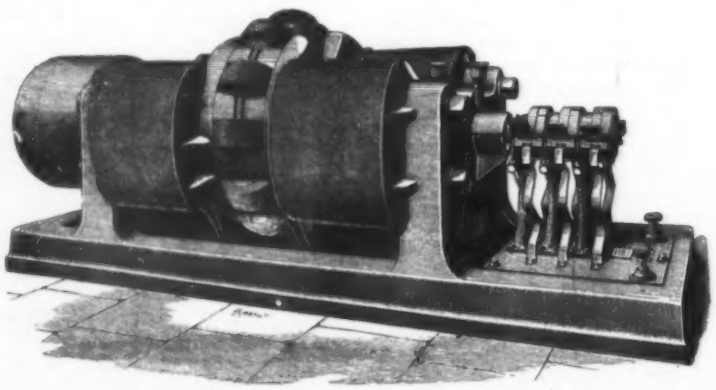


Fig. 10.—40-Light Brush Arc Dynamo. Type of 1881.

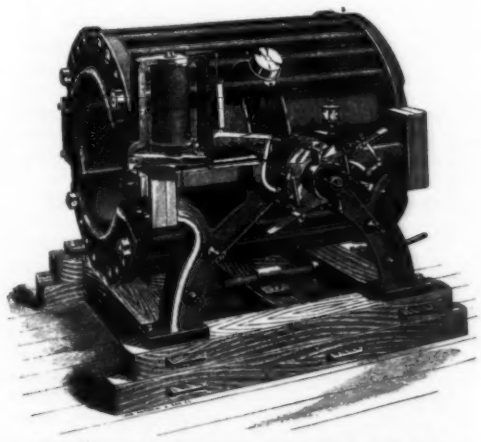


Fig 12.—50-Light Thomson-Houston Arc Dynamo. Type of 1886

small a current to increase it. Self-correcting influences would thus be at work at every incipient change of the current.

The third factor, self-induction, is one that has momentary influence only; it is electromagnetic inertia of a very transient sort. Its analogy to the mechanical inertia of a flywheel is helpful toward a clear understanding of its influence, and though ordinarily associated with the working of alternating currents, a brief explanation will be made at this point. A fly wheel tends to keep the motion uniform; it resists acceleration and retardation alike; the numerical value of the energy resident in the mass of the wheel varies as the square of the angular velocity. Likewise, when a diminution of the current from a dynamo is attempted, the reduction in the number of lines of force at once generates an electromotive force to prolong the current; in case of an actual break in the circuit the high self-induced voltage may produce a visible or even disastrous flash, just as the sudden stopping of a fly wheel may mean ruin to the connected machinery; a rise in the current immediately produces more lines of force, and they generate an electromotive force in the direction to check the current. To compensate for fluctuations in the driving of the engines, and irregularities in the burning and feeding of the carbons in the lamps, self-induction is a force for instantaneous remedy. Still resembling the mechanical case, the value of self-induction varies as the square of the number of turns in the coils, and as the arc dynamo has many turns it has very high self-induction.

Were these three qualities alone present in the dynamo, it would still be unsatisfactory in its operation; the current would have no particular value, and in spite of helpful influences, considerable variations would result from extreme changes of load. It is like a steam engine with heavy flywheel, long crank, and restricted steam ports; with steam supplied, it would run at some speed, though indeterminate, and vary with every change of load; even though the load were entirely removed the engine might not race on account of the protective effect of the narrow ports. Though the arc dynamo might supply too weak a current at extreme loads, the factors just explained might prevent a ruinous one on short circuit. For uniform engine speed over appreciable lapse of time the flywheel is helpless, and a "governor" is attached, so the arc dynamo needs the additional help of a mechanically operated "regulator." The voltage of a dynamo has been shown to be dependent upon the field flux, number of armature conductors and the speed. Just the right potential could always be secured by driving the dynamo at a suitable speed, but such a method would involve impracticable engineering. Of the two remaining chances, control by varying the field strength would involve departure from the desirable condition of high saturation, and varying the number of armature conductors from one moment to the next looks impossible. Brush actually adopted the method of varying the field strength, and thereby introduced the only weak point of his system; while Thomson, by varying the position of the brushes, changed the effective if not the real number of armature conductors, a device of marvelous sensitiveness and reliability.

Shunt-wound fields have been used on a small scale for series-connected arc lamps. Edward Weston, afterward the maker of electrical measuring instruments, adopted this kind on some 20-light dynamos; a mechanical governor was attached to vary the field rheostat, but the action was too sluggish to be satisfactory, and the current was apt to surge through wide variations. For extreme variations in the number of lamps a shunt winding could not possibly be effective, for the 50 volts required for one lamp might not be sufficient to enable the dynamo to start at all, and the several thousand volts acting at full load might burn out the winding. With the added expense of the fine wire for such coils, and the danger of rupture of the insulation, there is now no likelihood of considering other than the eminently satisfactory series winding.

Fig. 10 shows the appearance of the Brush machine for 40 lights; the integral casting of base and magnet yokes with their bearings for the shaft was an English construction; in Cleveland, two channel bars running lengthwise to which the upper castings were bolted made a lighter yet rigid construction, and one not likely to be broken in shipment; also for transportation to difficult locations, the machine could then be dismembered. Though comprised in four separate parts the field magnet has essentially only two poles, for those facing each other are of the same polarity, and except for interference with access to the armature might be joined together. In some of his dynamos for electroplating Brush actually made the iron continuous, as did Gulcher and some others who copied freely from the Brush design. The location of the commutator brushes at lines 180 deg. apart instead of 90 deg., as required with four poles, is proof of the existence of two poles only. The armature is a cast iron ring of short axial, but considerable radial length. Twelve deep and wide slots hold the coils of copper wire wound in a manner apparently resembling Gramme's; it differed from his, however, in the essential respect that adjacent coils were not connected together, and to a multiple segment commutator, but opposite coils were joined in series, and to a two-segment commutator; other opposite coils were also connected in similar manner, each pair having a two-segment commutator of its own. Coils occupying positions 90 deg. apart could momentarily be put in multiple with each other by the bridging action of the brushes, but the separate groups of commutators were connected in series, while the coils passing through the neutral line were completely cut out of circuit. A diagram of the circuits of the 8-coil 16-light machine is given in Fig. 11. The wires that connect the opposite coils in series are not shown, but they do not take the S-shaped path, as erroneously given in some text books; the true directions of the current result in producing consequent poles in the armature core, not in driving the magnetism in the closed circular path. The curved pole pieces seen in Fig. 10 are omitted from the diagram; their real effect along with the great distortions produced by the armature reactions will explain the extreme shifting of the brushes from their expected position. Imagining the current to start at the negative brush *A*, it enters the coils numbered 3, then out of the brush *A'* to *B;* coils 2 and 4 are for a moment in parallel, and the current unites again at brush *B'*, and passes around the field coils, then through the lamp circuit and back to *A*. Brush suspected a fault in the ordinary Gramme winding, thinking that under some conditions there was a chance for the current to go backward through the closed circuit. This idea was of course not well founded, and it is curious to notice that the condition which he wrongly suspected in the other armature, he actually introduced in his own. The two coils which he allowed to be put in parallel have equal electromotive forces for the merest instant only; before and after that instant, they are by no means equal, and one coil becomes a short circuit for the other; the high self-induction of the coils, however, prevented the fault from doing harm, and the connection gave momentarily the benefit of a reduced armature resistance. When, later, Brush tried the same device on low-potential machines with negligible self-induction, the method was obviously inappropriate, and compelled him to adopt the simple Gramme connections. The "open-coil" arc dynamos at once won popular favor, and made public lighting on a large scale possible. The inventor is now recognized as the "Father of Arc Lighting."

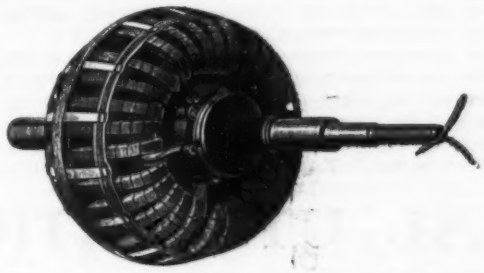


Fig. 13.—Thomson-Houston Ring Armature

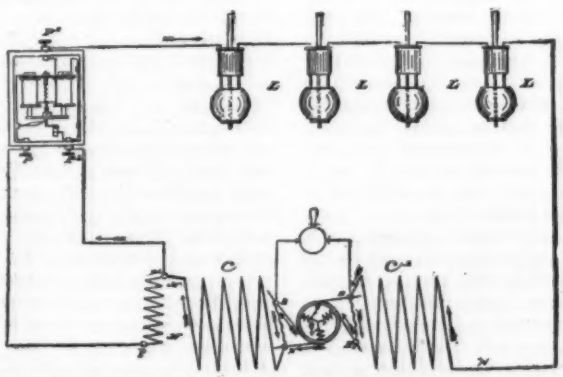


Fig. 14.—Thomson-Houston Connections for Dynamo, Regulator and Lamps.

The regulator devised by Brush consisted in creating a variable by-pass, or shunt, to the field winding. A doubly wound solenoid was arranged, so that the movement of its core, acting through a lever, would vary the pressure on a column of carbon plates; the greater the pressure, the lower their resistance, and more of the current would pass through them instead of flowing through the field windings. The main current, which it was desired to keep constant, passed through one of the windings of the solenoid, and the field current passed through the other. A slight variation in the main current would thereby be reinforced by the considerable change in the field current to assist in the necessary action. The regulator was adjusted for any desired value of the current by assisting or opposing the pull of the solenoid by an adjustable spiral spring. Between half and full load the regulator acted very well, but on very light loads, the solenoid, though checked by a glycerine dash pot, made altogether too erratic movements, and allowed the current to surge through extreme ranges. The reason lies in the qualities of the iron of the field for holding "residual" magnetism; taking away a desired portion of the exciting current does not necessarily take away the magnetism, and increasing the current a little does not at once increase the magnetism. When considerable change of current is made, the magnetism does alter, but by altogether too much in value. By use of wrought-iron cores and laminated pole pieces in the latest machines, this tardy and extreme action is considerably lessened.

Within a few years after making the first dynamos Brush replaced the solid armature cores with laminated ones. Their higher permeability allowed a greater magnetic flux, and their cooler running and greater tensile strength permitted higher speeds, so that the 16-light size became of 25, and the 40-light of 65 lights capacity. "Half-arc" machines for 6½ amperes instead of 10 were constructed, the machines being wound with more turns of finer wire, and would light 40 and 85 lamps respectively. An idea of the winding of the armature of the 40-light 6½-ampere is given by stating that each of the eight coils consists of 48 turns per layer and 22 layers of No. 15 wire, weighing about 15 pounds.

The Thomson-Houston dynamo is of peculiar construction. Its armature is spherical, and when the drum type was used was certainly difficult to wind; the field magnet is prodigal of wire, and access to the armature is awkward. With two field poles, the three commutator segments and four brushes, the machine stands unique among dynamos. Its one qualification is that it works marvelously well under all changes of load; the full number of lamps can be turned on and all but one suddenly turned off, and that one will "shine on" with almost imperceptible change. Even on a short circuit the current will not rise to a ruinous value. The regulator is perfect. It consists in automatically moving the brushes to such positions as enable just the right potential to be available; the full current always flows around the field, a feature unduly wasteful at light loads, but keeping the iron saturated. By arranging the main brushes to be capable of considerable movement, and the second set—in multiple with the other—to have a coincident movement about one-third as far in the opposite direction, Prof. Thomson was able to add the electromotive of two coils together to get a maximum, or to oppose them to each other to get a minimum, intermediate values being obtained by intervening positions of brushes. A surprisingly small movement is all that is needed to compensate for ordinary changes in the circuit. With only one commutator and that consisting of but three segments, there was sure to be considerable sparking, but the 3- and 6-light machines were able to withstand it. Beginning with the 12-light size, the current would flash around the commutator in preference to lighting the lamps. The inventor proceeded heroically to blow out the sparks, and the centrifugal blower mounted on the shaft just back of the commutator became at once a distinctive and necessary adjunct; it was highly effective even in the 50- and 65-light sizes of machines, but not reliable for potentials much over 3,000 volts. Most of the noise attending the operation of these dynamos comes from the angry snapping or rupturing of these incipient arcs. Movement of the brushes to follow the demands of the circuit is furnished by a direct-acting electromagnet mounted on one corner of the machine.

A view of the standard 50-light size of the Thomson-Houston dynamo is given in Fig. 12. The field cores are hollow in order to concentrate the magnetism in the remaining portion; polar faces are cup-shaped so as to act properly on the spherical armature. Levers for actuating the brushes are readily recognized, the electrical connection between two brushes being main-

tained by tubular sliding contacts; the two blower nozzles are seen at top and bottom of commutator just ahead of the secondary set of brushes. A view of the ring armature adopted in 1888 is given in Fig. 13. The narrow units into which the winding is divided are to enable the individual coils to be wound in forms and slipped in place on the core through a narrow crevice. This opening is finally filled and locked with a T-shaped laminated wedge. The original drum armature could be wound by experts only; the ring had the qualifications of higher self-induction and better insulation, and could be repaired or entirely rewound by any clever station attendant. The scheme of connecting the coils imitates Brush's armature; five coils in one group are connected in series with each other and then in series with the opposite group; one of the final terminals is led to the hoop on the wooden ring in the front of the figure and the other end to a commutator segment; two other groups are similarly formed and symmetrically connected to hoop and segments.

Fig. 14 shows a diagram of connections of dynamo, regulator, controller and lamp circuit. Before starting, the armature is normally short-circuited by means of the small switch just above the commutator. If revolving, the armature generates some current, for the residual magnetism of the field may be considerable. The regulator arm is then lifted to the highest point, that of minimum potential; then the switch is opened. The small current that was flowing in the highly inductive armature continues to flow, but is compelled to traverse the entire circuit; the field is excited, the lamps start, and brushes fall to the position to fit the demands. Two paths are observed as possible from the left-hand side of dynamo to the "controller" that may be located conveniently near the machine; one of these paths includes the regulator magnet; the other does not. A solenoid is included in the main circuit; a current above normal lifts the core, breaking the short path from the dynamo, and compelling the current to traverse the regulator magnet. The brushes are thereby lifted to a position of lower voltage and consequently less current; when below normal current, the solenoid will drop its cores, and short-circuit the regulator; by force of gravity the heavy armature of the regulator will then fall and move the brushes to a position of higher potential. A dash-pot prevents too sudden or wide movements. The attempt is not made to hold the current at an absolutely constant value, but to admit the inevitable, and confine the variations to narrow limits. A variation of half an ampere really suffices to operate the controller, while the actual power to move the brushes comes from the energetic electromagnet. The simplicity, reliability and "fool-proof" qualities of the Thomson-Houston regulator accounted for its commercial popularity over the more "finicky," though more economical, Brush construction. Added to the inherent good working qualities of the machines the aggressive activity of the company's management, and some reason for the phenomenal success of the "T-H" system is accounted for.

Arc dynamos with closed coil ring armatures are made by some firms; the commutators are more expensive in first cost and suffer more from the sparking and burning than the other sort. In case of accidental rupture of the circuit, the flash that results is more dangerous to the winding than the simple "spilling" over the commutator experienced with the open coil winding. In ordinary running, such small differences exist between the two types that it is easy to find those who champion each with equal zeal.

In modern central stations it is common to find arc dynamos driven by electric motors; the appearance of some such "units" along with explanations of the switching and accessory devices will be given in later articles; the next one will be on "Arc Lamps."

(To be continued.)

THE ECONOMICAL UTILIZATION OF LABOR.*

CONSIDERATIONS GOVERNING EFFICIENCY.

BY HENRY L. GANTT.

THOSE who have given even superficial study to the subject of labor are beginning to realize the enormous gain that can be made in the efficiency of workmen if they are properly directed and provided with proper appliances. Few, however, have realized another fact of equal importance, namely, that to maintain permanently this increase of efficiency the workman must be allowed a portion of the benefit derived from it. To successfully obtain a high degree of efficiency, however, the same careful scientific analysis and investigation must be applied to every labor detail as the chemist or biologist applies to his work. Wherever this has been done, it has been found possible to reduce expenses and at the same time to increase wages, producing a condition satisfactory to both employer and employee.

Wherever any attempt is made to do work economically the compensation of the workman is based more or less accurately on the efficiency of his labor. Very fair success in doing this has been accomplished in day work by keeping an exact record of the work done each day by every man and by fixing his compensation accordingly. This method, however, falls very far short of the highest efficiency, for very few workmen know the best way of doing a piece of work, and scarcely any have the ability to investigate different methods and select the best. It often happens, then, that a man working as hard as he can falls very far short of what may be done, on account of employing inferior methods, inferior tools, or both.

We can never be certain that we have devised the best and most efficient method of doing a piece of work until we have subjected our methods to the criticism of a complete scientific investigation. Many people who have been accustomed to seeing an operation performed in a certain way, or even to performing it in that way for a number of years, imagine they know all about it, and resent the intimation that there may be some better way of doing it. Anybody, however, who carefully analyzes the sources of his methods will find that the mass of them are either inherited, so to speak, from his predecessor, or copied from his contemporaries. He will find that he knows but little of their real origin, and consequently has no ground on which to base an opinion as to their efficiency.

Even such a simple operation as shoveling is done very uneconomically in many places. The writer has seen the same shovel used for coal, ashes, and shavings, and this when coke forks were available for the shavings. The foreman had apparently given the subject no study and was content if the men were at work. The idea of working efficiently had never occurred to him. This is, of course, an extreme case, but it is a real one, and all degrees of efficiency exist between this and the case where each workman is provided with the proper implement and given a specific task, for the accomplishment of which he is awarded extra compensation.

Having determined thus the amount of work that a man can do, we can usually get it done if we offer the proper wages for doing it, and furnish an instructor who will teach the workman how to do it. In order to get the best results the following four conditions are necessary: First, complete and exact knowledge of the best way of doing the work, proper appliances and materials. Second, an instructor competent and willing to teach the workman how to make use of this information. Third, wages for efficient work high enough to make a competent man feel that they are worth striving for. Fourth, a distinct loss in wages in case a certain degree of efficiency is not maintained. These four conditions for efficient work were first enunciated by Mr. Fred W. Taylor, and when they are understood their truth seems almost axiomatic. They are worthy of very careful consideration.

Let us study these steps one at a time. The first is a scientific investigation of how to do the work and how long it should take. The fact that any operation, no matter how complicated, can be resolved into a series of simple operations, is the key to the solution of many problems. Study leads us to the conclusion that complicated operations are always composed of a number of simple operations, and that the number of elementary operations is often smaller than the number of complicated operations of which they form the parts. The logical method, therefore, of studying a complicated operation is to study the simple operations of which it is composed, a thorough knowledge of which will always throw a great deal of light on the complex operation. Also the time needed for performing any complex operation depends upon the time of performing the simple operations of which it is composed. The natural method, then, of studying a complex operation is to study its component elementary operations. Such an investigation divides itself into three parts, as follows: An analysis of the operation into its elements; a study of these elements separately; a synthesis or putting together the results of our study.

This is recognized at once as simply the ordinary scientific method of procedure when it is desired to make any kind of an investigation, and it is well known that until this method was adopted science made practically no progress. If it is desired to obtain the correct solution of any problem, we must follow the well-beaten paths of scientific investigation, which alone have led to reliable results. The ordinary man, whether mechanic or laborer, if left to himself, seldom performs any operation in the manner most economical, either of time or labor; and it has been conclusively proven that even on ordinary day work a decided advantage can be gained by giving men instructions as to how to perform the work they are set to do. When these instructions are the result of scientific investigation, the gain in efficiency is usually beyond our highest expectations.

It is well known that nearly every operation can be, and in actual work is, performed in a number of different ways; and it is self-evident that all of these ways are not equally efficient. As a rule, some of the methods employed are so obviously inefficient that they may be discarded at once, but it is often a problem of considerable difficulty to find out the very best method. It is only by a scientific investigation that we can hope even to approximate the best solution of any problem.

To analyze every job and make out instructions as to how to perform each of the elementary operations requires a great deal of knowledge, much of which is very difficult to acquire; but the results obtained by this method of working are so great that the expenditure to acquire the knowledge is comparatively insignificant.

It has been demonstrated that whether the labor is that of a Pennsylvania Dutch workman in a machine shop, a Hungarian laborer handling stock in the yard of a steel works, or a skilled cloth handler in a bleachery, the amount of work the average workman does under the ordinary conditions is only about one-third of what can be done by a proper workman under the best conditions. In other words, when a man sets his own task, as he virtually does in ordinary day work, he usually does about one-third of what a good man fitted for the work can do under the best conditions.

As a result of our first step or our scientific investigation, we find, in general, that it is possible to do about three times as much as is being done; the next problem is how to get it done. First, I wish to say that no matter how thoroughly convinced we may be of the proper method of doing a piece of work and of the time it should take, we cannot make a man do it unless he is convinced that in the long run it will be to his advantage. In other words, we must go about the work in such a manner that the workman will have confidence in us and feel that the compensation offered will be permanent. When we have established this condition of affairs we are ready to start a workman on the task, which, when properly set after an investigation, is such as can be done only by a skilled workman working at his best normal speed.

The average workman will seldom be able at first to do more than two-thirds of the task, and, as a rule, not more than one out of five will be able to perform the task at first. By constant effort, however, the best workmen soon become efficient, and even the slower ones often learn to perform tasks which for months seemed entirely beyond them.

Buying labor is one of the most important operations in modern manufacturing, yet it is one that is given the least amount of study. Most shops have expert financiers, expert designers, expert salesmen, and expert purchasing agents for everything except labor. The buying of labor is usually left to people whose special work is something else, with the result that it is usually done in a manner that is very unsatisfactory to buyer and seller. It is admitted to be the hardest problem we have to face in manufacturing to-day, and yet it is considered only when the manager "has time" or "has to take time," or on account of "labor trouble." The time to study this subject is not when labor trouble is brewing, but when things are running smoothly and employer and employee have confidence in each other.

Men as a whole (not mechanics only) prefer to sell their time rather than their labor, and to perform in that time the amount of labor they consider proper for the pay received. In other words, they prefer to work by the day and be themselves the judges of the amount of work they shall do in that day, thus fixing absolutely the price of labor without regard to the wishes of the employer who pays the bill. While men prefer, as a rule, to sell their time and themselves determine the amount of work they will do in that time, a very large number of them are willing to do any reasonable amount of work the employer may specify in that time, provided only they are shown how it can be done and paid substantial additional amounts of money for doing it. The additional amount needed to make men do as much work as they can depends upon how hard or disagreeable the work is, and varies from 20 to 100 per cent of their day rate.

* Abstracted from a lecture before the senior class of Stevens Institute of Technology.

These facts are derived from experience and give us a key to the intelligent purchase of labor. For instance, if we wish to buy the amount of labor needed to accomplish a certain task, we must find out exactly and in detail the best method of doing the work, and then how many hours' labor of a man suited to the task, working at his best normal rate and by the methods prescribed, are needed to perform it.

This is simply getting up a set of specifications for the labor we wish to buy, and is directly comparable to a set of specifications for a machine or a machine tool. The man who buys the latter without specifications is often disappointed, even though the manufacturer may have tried earnestly to anticipate his wishes; and the man who buys the former under the same conditions has in the past almost universally found that a revision of his contract price was necessary in a short time. The relative importance of buying labor and machinery, according to the best knowledge we can get, and the best specifications we can devise, is best illustrated by the fact that while the purchase price of a machine may be changed whenever a new one is bought, that of the labor needed to do a piece of work should be practically permanent when it is once fixed. As I have said before, few men can work up to these specifications at first, if they are properly drawn, but many men will try if they are properly instructed and assured of the ultimate permanent reward. Most men will not sacrifice their present wages to earn a higher reward in the future, and even if they were willing, few men could afford to. Therefore, while they are learning to perform the task, they must then be able to earn their usual daily wages, and the reward for the accomplishment of the task must come in the form of a bonus over and above their daily wage.

It is these considerations that lead to the development of the bonus system of paying labor, under which a man always gets his day's wages. If he accomplishes the task in the time and manner specified, he gets in addition a bonus the size of which depends upon the severity of the work. The easiest way to figure such a bonus is to make it a proportion of the time allowed; for instance, if from our time study we find that three hours is a reasonable time for a job that has usually taken from five to ten hours, we set three hours as the time limit and pay the workman one-third more, or for four hours, if he does the work in three hours or less.

If he does it in exactly three hours he gets pay for four hours, or an increase of 33 1-3 per cent. If the work is done in two and one-half hours he gets pay for four hours, or an increase in wages per hour of 60 per cent. If the work is done in two hours his pay is still that which he would ordinarily get for four hours, an increase of 100 per cent. If the study of the work has been carefully done, and the task is properly set, it will but seldom occur that a workman can do in two hours the task for which he was allowed three. We sometimes find, however, that an exceptional man will do in two and one-half hours work that a good man will need three hours for. The large increase of wages such a man can earn amply compensates the exceptional man for devoting his time to the work. When the more skilled have been earning their bonus for some time, and the less skilled begin to realize that the prize is real and worth striving for, they make every effort to attain it and rapidly improve in skill. This increase in efficiency makes the payment of high wages possible, and it may be added that without efficient labor permanent high wages cannot be paid indefinitely, for every wasteful operation, every mistake, every useless move has to be paid for by somebody, and in the long run the workman has to bear his share.

Good management, in which the number of mistakes is reduced to a minimum, and useless or wasteful operations eliminated, is so different from poor management, in which no systematic attempt is made to do away with these troubles, that a man who has always worked under the latter finds it extremely difficult to form a conception of the former. The best type of management is that in which all the available knowledge is utilized to plan all work, and when the work is done strictly in accordance with the plans.

The best mechanical equipment of a plant that money can buy avails but little if labor is not properly utilized. On the other hand, the efficient utilization of labor will often overcome the handicap of a very poor mechanical equipment, and an engineer can have no greater asset than the ability to handle labor efficiently.

THE ORIGIN OF RADIUM.*

THE SEARCH FOR THE PARENT ELEMENT.

BY BERTRAM B. BOLTWOOD.

RUTHERFORD has recently given an account of some experiments in the course of which a solution of actinium was successively precipitated with ammonium sulphide in order to remove the radium present. From the results obtained he concludes that the parent of radium is distinct from actinium, and is separated from the latter by precipitation with ammonium sulphide.

For the past ten months I have been experimenting with the object of determining more definitely the properties and chemical behavior of this elusive parent. The general manner of proceeding has been to obtain as complete a solution as possible of known weights of different uranium minerals. The growth of radium in the solutions of the rare earths finally obtained was determined by measurements of the amount of radium emanation present at frequent intervals, and the rate of growth was calculated by an expression which took into account the rate of production of the emanation by the radium. The minerals used included carnotite, Joachimsthal pitchblende, gummite, uranophane, and a specimen of very pure uraninite from North Carolina containing only 0.03 per cent of material insoluble in dilute nitric acid.

In confirmation of Rutherford's statement it was found that the rate of production of radium was not influenced appreciably by the presence of radio-actinium and its products, which were completely absent from most of the solutions at the start. Continued observations of the growth of radium in the first solution prepared indicate that the rate of production of radium has been constant, within the limits of experimental error, for a period of more than five hundred days.

I have attempted with one of my preparations to repeat the separation of the radium parent from actinium by the ammonium sulphide treatment which Rutherford has described. No separation could be detected when freshly prepared, pure ammonium sulphide was used. It was found that the radium parent can be quite completely separated from actinium by repeated precipitation with sodium thiosulphate under the conditions usual for the precipitation of thorium. In the case of a solution of the parent substance with thorium and other rare earths treated in this manner, less than 1 per cent of the parent present remained in the filtrate, as was shown by the growth of radium in the two fractions obtained in this process. Since ammonium sulphide is always open to suspicion unless freshly prepared, and since on standing in loosely stoppered bottles it ultimately changes wholly into ammonium thiosulphate, it appears probable that the separation noticed by Rutherford was due to the latter reagent.

An interesting relation has been noticed between the growth of radium and the activity of the substances other than thorium in my solutions containing the radium parent. This proportionality is quite striking in those solutions containing the more completely purified salts. The activity of the substance present in these salts is comparatively high, and is about equal to the activity of the radium (itself) with which it is associated in the mineral. More significant still is the fact that this radio-active substance does not appear to possess any of the characteristic properties of the recognized radio-active elements. It is impossible that it is uranium, thorium, radium, or polonium. It has none of the properties that have been given as characteristic of actinium. About four-tenths of a gramme of thorium oxide, containing an amount of this new body sufficient to give a leak of five hundred divisions per minute in an α-ray electroscope, did not produce sufficient actinium emanation to permit its detection in another electroscope of greater sensitiveness. The thorium oxide had been prepared some weeks before by the gentle ignition of the oxalate, and was very porous. A strong current of air, about four liters per minute, was drawn over the preparation. There was no difficulty in measuring the thorium emanation evolved by this material under these conditions.

That the active substance is not actinium is also indicated by the fact that from a solution more than five months old no active substances other than thorium products could be separated by treatment with ammonia, by the formation of finely-divided sulphur from sodium thiosulphate, or by the precipitation of considerable quantities of barium sulphate in the solution. The first process should have separated actinium X, and the two last should have separated radio-actinium had these products been present. The solution contained about 3 grammes of thorium and a quantity of the new substance having an activity equal to that of about 35 grammes of pure uranium.

Another important matter is the behavior of the oxides obtained by strongly igniting the hydroxides precipitated by ammonia from a solution similar to the above. The activity of these oxides remains nearly constant for long periods, showing only a slight initial rise corresponding to the formation of thorium X in the thorium present. No rise corresponding to the formation of actinium X can be observed, but if actinium were present a separation of this product would be expected.

For these and certain other reasons I think that there is good cause for believing that uranium minerals contain an element emitting α rays, which is different from the other elements that have been identified, which produces no emanation, and which resembles thorium in its chemical properties. The activity of this element appears to be about the same as that of the radium itself with which it is associated in minerals. It is without doubt a product of uranium, and is probably the immediate parent of radium. It is very likely that this body is contained in Debierne's actinium preparations and in Giesel's "emanium" compounds, especially in the former, and its presence may perhaps explain the confusion which has resulted from Debierne's earlier assertions that actinium accompanied thorium as opposed to Giesel's positive statements to the contrary. The proportion of the total activity of a mineral due to the actinium present is very small, for the activity which can be attributed to actinium is less than 9 per cent of the total.

The rate of disintegration of radium as determined from its growth in preparations similar to those described above, separated with great care from very pure North Carolina uraninite, indicates that the half-value period of this element is about 1,900 years. It is hoped that certain experiments now in progress will make it possible to determine this factor with a satisfactory degree of certainty.

* Abstracted from Nature.

COAL MINED BY MACHINES.

ONE of the notable features presented by the statistics of bituminous coal production in 1906, as in 1905, was the increase in the use of machines and in the quantity of machine-mined coal. The percentage of increase in the production of machine-mined coal in 1905 over 1904 was greater than the percentage of increase in the total production. In 1906 the quantity of machine-mined coal was 15,451,075 short tons greater than in 1905, while the total production of bituminous coal increased 21,534,643 tons, showing that 72 per cent of the increase in 1906 over 1905 was in the machine-mined product. The statistics also show that the average output for each machine in use increased from 10,258 tons in 1904 to 11,258 tons in 1905, and to 11,638 tons in 1906.

The total quantity of coal produced by the use of machines in 1906 was 118,847,527 short tons, as against 103,396,452 short tons in 1905 and 78,606,997 short tons in 1904. The increase in 1906 was 15,451,075 short tons, or 15 per cent. The number of machines in use increased from 7,663 in 1904 to 9,184 in 1905 and to 10,212 in 1906.

The percentage of the machine-mined tonnage to the total production in the States in which machines are used has increased steadily each year. In 1899 this percentage was 23; in 1900 it was 25.15; in 1901, 25.68; in 1902, 27.09; in 1903, 28.18; in 1904, 28.78; in 1905, 33.69, and in 1906, 35.1.

Of the 10,212 machines in use in 1906, 5,911, or 58 per cent, were of the pick or puncher type; 4,144, or 40.5 per cent, were chain-breast machines, and 157, or 1.5 per cent, were long wall.

In the number of machines in use and in the amount of machine-mined tonnage, as in the total production of coal, Pennsylvania stands far in the lead, with 45 per cent of the number of machines and 45.6 per cent of the machine-won product in 1906. The amount of coal mined by machines in Pennsylvania increased from 49,335,660 short tons in 1905 to 54,146,314 short tons in 1906. West Virginia ranks second in the number of machines in use, with 1,322, closely followed by Ohio, with 1,255. The position of these two States is reversed in the amount of coal mined by machines, Ohio's production by machines in 1906 being 20,004,416 short tons, while West Virginia's was 15,565,113 tons. Ohio stands first in the percentage of machine-mined coal to the total product. Illinois, the third State in coal-producing importance, ranks fourth in the production by the use of machines. Kentucky, the eighth in rank among the coal-producing States,

takes fifth place in the number of machines used and machine-mined tonnage, and second in the percentage of the machine-mined coal to the State total. Indiana comes next to Kentucky in the use of mining machines. The six States mentioned contribute over 90 per cent of the total machine-mined coal.

ELECTRICAL NOTES.

The New York Edison Company has arranged for a series of weekly lectures to be given at their address, 44 West 27th Street, New York, and open to all its employees. The course comprises twenty lectures, which will be given by Prof. Sydney W. Ashe, B.S., E.E. Each lecture will be repeated so as to give both day and evening employees opportunity to attend.

On the German state railways accumulator cars have been running since last February on three railway lines. The new cars run four to six times a day over a distance of about eight miles. The cars are three-axle cars built especially for this purpose. The batteries consist of 180 cells of 200 ampere-hours capacity. A car battery weighs about 10 tons and yields 685 kilowatt-hours. The car complete weighs 38 tons.

A miniature head telephone has been developed in Sweden, according to a consular report. The receiver is said to measure ½ inch by ⅝ inch, and over the diaphragm may be screwed a cover continued into an ear tip. The connection to the receiver may be a fine flexible cord carried like an eyeglass cord. No helmet or other attaching device is required to hold the receiver in place. The instrument is thought to be valuable both to telephone operators and to individuals with defective hearing, the latter also carrying a transmitter, etc., on the person. The device was invented by the chief of the government telephone department.

A notable example of the growth of trolley lines is furnished by the line which will link Chicago to St. Louis. Much of this line is in operation and it is expected that in little more than twelve months sleeping cars will make the journey between the cities in about ten hours, traveling at a rate of about 30 miles an hour. The Illinois Traction Company, who own the line, already operate about 470 miles of track and have about 200 miles additional under construction or projected. The system, which is a holding concern for a large number of subsidiary companies, is engaged not only in the conduct of an interurban business, but has found it practically indispensable to operate local street car railways, and, in addition to that, electric light, power, gas, and heating corporations in the different towns along the line. It operates the street railroads of Venice, Madison, Granite City, Jacksonville, Quincy, Peoria, Bloomington, Decatur, and many other towns. In many of these towns the lighting and heating plants are under the same control, so that one gains an idea of what a great network of electrical enterprises must be built up to maintain an extensive interurban system.

A recent issue of the Physical Review publishes a preliminary report dealing chiefly with the arc between iron and copper terminals. The report is the work of Mr. H. D. Arnold and Mr. W. G. Cady. It is stated that the so-called iron arc is, in air, an arc between molten globules of magnetic oxide of iron. By letting the arc burn until it has become normal, observations can be made that compare in accuracy with those in the case of the carbon arc. The difficulty encountered in obtaining reliable observations in the neighborhood of one ampere led Mr. Arnold to the detection of an abrupt change in the iron arc analogous to the hissing point of the carbon arc. For currents below one ampere the arc burns quietly, and there is no well-defined spot of light on the globule at the anode. As the external resistance is decreased so that the current increases beyond a value depending largely on the curvature of the globule, the arc suddenly contracts, a bright spot appears on the anode, hissing commences, potential difference drops, and current increases slightly. Experiment showed that the effect is confined mainly to the anode. When the current is decreased, the change back to the quiet stage does not take place until the current has become smaller than it was when hissing commenced, due, doubtless, to the high temperature at the anode. The spectrum of the iron arc shows no change, at the hissing point, beyond a general brightening of lines. When the current is increased to about two amperes, the iron arc emits a whistling sound, and the spot at the anode has a tendency to travel around rapidly, describing a circular ring. With copper electrodes, 6 millimeters thick, the hissing point occurs when the current is about 0.5 ampere, with about 110 volts across the arc. The arc between aluminium electrodes was too unsteady for the detection of the effect. Zinc has thus far shown no hissing point. Something resembling a hissing point was found with an arc in air between a mercury anode and carbon cathode, but this may have been due to disturbing causes. Lecher's assertion that the iron arc is a discontinuous discharge, while the copper arc is perfectly continuous, was put to the test for both the quiet and hissing stages. A bolometer was substituted for the hot wire used by Lecher, but it soon became evident that the capacity and self-induction of the bolometer circuit tended to set up oscillations, causing a "singing" iron arc. Good results were obtained by connecting a self-inductance of low resistance in series with the arc. The conclusions arrived at were briefly as follows: the carbon and iron arcs, when quiet, are continuous; when hissing, they are oscillatory. The copper arc seems always to be oscillatory, and the smaller the current the more is the bolometer heated. This point, as well as bolometric tests with other metals, is soon to be investigated.

ENGINEERING NOTES.

A new turbine torpedo will shortly be tested in France of greater speed than any at present in existence, capable of traveling a distance of over 1,250 miles and of carrying a much larger charge of explosives than any torpedo now in use.

German ironmasters are suffering from the scarcity of iron ore supplies. The Rhenish-Westphalian blast furnaces import 40 per cent of their ore from Sweden and an equal amount from the Luxemburg-Lorraine districts, and complain that the quality is poor.

On the Harriman railroads private refrigerator cars have been displaced by the companies' own equipment. Six thousand six hundred cars of the latest type have been provided at a cost of about $11,000,000. More than 5,000 of them have been delivered to the Southern Pacific.

The steamship "Kabinga" sailed from New York recently with a 12,000-ton cargo of steel equipment for the Manchurian Railroad, furnished chiefly by the United States Steel Corporation. Within the next twelve months 163,000 tons of rails, 8,000 tons of bridges, 250 locomotives, and 3,000 cars will be shipped to Dalny, the principal seaport terminus of the South Manchurian system.

The government manufacture of peat fuel in Sweden, says the Iron and Coal Trades Review, has been abandoned owing to the cost and the unsatisfactory fuel value of the production. More than thirty years ago an enterprise was started for the production of peat fuel for locomotive and household purposes, and a very good coke was likewise made; but, nevertheless, the undertaking ceased.

In a recent article in the Street Railway Journal on "Transportation Facilities in South America," it is stated that transportation is so difficult over the mountains that the coal imported into Bolivia for the railway's own use costs about $30 per ton. At La Paz abundant timber grows within fifty miles from the mountains, but transportation is so difficult that trolley poles and lumber for building operations are brought from Oregon, a distance of thousands of miles.

In a recent issue of the Annales des Ponts et Chaussées, M. H. Le Chatelier contributes an article regarding the action of sea water on cement and concrete, in which he states that all hydraulic binding agents without exception may be decomposed by sea water, although the rate of this action varies within wide limits. The most essential condition to render cements immune from decomposition in the sea is to reduce as much as possible the volume of water employed in gaging the cements.

It has recently been shown, says the Engineer, that in large presses the compressibility of the water is not negligible. The change of volume of the water due to compression may be much greater than that of the cylinders and pipes containing it, due to the pressure. With a 2,500-ton press the loss of volume of the water in the system was equal to one-sixth the volume of one stroke of the pump, while the increase of the volume of the cylinders and pipes was 1/17 of the compression of the water, the stretching of the press columns corresponded to 1/21, and the bending of the crosshead to 1/16 of the compression of the water.

The connection between radium and the safe working of collieries does not at first sight appear to be a very intimate one, says Nature, but the discovery announced by Profs. Elster and Geitel in Die Welt der Technik, that fire damp contains six or seven times the amount of radium emanation that is generally found in the air of coal mines, brings the two into close relation with each other. Comparative tests of the electrical conductivity of the air due to the presence of the emanation can readily be made by means of a simple aluminium foil electroscope, and as only a comparatively small sample of the gas is necessary, the tests may be carried out outside the mine.

A subterranean canal, 4.3 miles in length, is projected to connect the valley of the Rhone with the port of Marseilles. This tunnel will be, in point of quantity of material excavated, the largest in the world. It is estimated that 2,840,000 cubic yards will be excavated, against about 1,375,000 cubic yards for the Simplon tunnel. The latter is 13.8 miles long, but only 24 feet wide and 18 feet high; while the canal tunnel would be, with the towpaths on either side, 66 feet wide and 42 feet high. The canal would permit two barges to pass at any point. The cost of the tunnel is estimated at $6,900,000. The total cost of the canal will be $15,200,000.

TRADE NOTES AND FORMULÆ.

To Clean Old Medals.—Immerse them in lemon juice until the oxidation is entirely removed. A full day is generally sufficient. A longer stay, however, is not disadvantageous.

Tin Foil, Alloys for.—

	Tin.	Copper.	Lead.	Iron.	Nickel.
Mirror foil	97.60	2.16	0.04	0.11	0.00
Jews' foil	98.47	0.38	0.84	0.12	0.00
Ger. "Stanniol"..	96.21	0.95	2.41	0.09	0.30

Strong Powdered Glue, Soluble Cold.—

Carbonate of potash.....	1 part.
Alum	1½ parts.
Ordinary glue or fish glue.....	10 parts.
Water	4 parts.

The whole is mixed and boiled, dried by ordinary methods, and then pulverized. It is applicable to any use.

Attachment of Paper to Glass.—To fasten paper labels or tickets on glass, the employment of liquid glass (silicate of soda) is recommended, taking care not to spread the product on the paper, but on the glass, and then apply the dry paper. This will immediately become fastened, and when dry cannot be detached. The silicate should be slightly diluted and spread on the glass with a rag or small sponge, and the paper object applied carefully.

Production of Soldering Compounds for Jewelers.—

Fusible White Solder.

Copper	45 parts.
Zinc	50 parts.
Tin	3½ parts.
Lead	1½ parts.

Very Fusible White Solder.

Copper	57 parts.
Zinc	28 parts.
Tin	15 parts.

Soft Solders.

Brass	70	77	77 parts.
Zinc	18	18	23 parts.
Tin	12	5	.. parts.

To Imitate Old Silver.—To impart the appearance of age to silver, it is sufficient to oxidize the surface. A liquid which will give the characteristic brown coloration to the metal is composed of two parts of ammonium chloride, two parts of cupric sulphate, one part of nitrate of potash, and five parts of acetic acid. When the whole of an object is to be colored, it is to be heated first and then dipped in the bath. But when certain parts only are to be oxidized, a camel's hair brush should be used, and the liquid applied at these points. Another method is to immerse in a bath composed of a solution of one-tenth of sulphydrate of ammonia in water, and rubbing afterward with a glass-wire brush. On polishing with an agate burnisher, the objects will remain colored a beautiful dark brown. Or,

Immerse the objects to be oxidized in one of the following baths: Hot potassium sulphide; hot ammonia sulphydrate, with the addition of one-tenth of hot perchloride of iron; concentrated extract of javelle water; or a bath composed of equal parts of cupric sulphate and sal-ammoniac in strong vinegar. The objects are kept in these baths only the necessary time for obtaining the shade desired. To produce very white surfaces, pass over them lightly a wad dipped in a solution of potassium cyanide. The reliefs will be white, and the sunken portions oxidized. For pieces silvered lightly, strong baths must not be used, for then the silvering would disappear and the copper be laid bare. The pieces when taken from the bath must be washed several times in water and dried thoroughly. In handling potassium cyanide it must not be forgotten that it is a violent poison.

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